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ROYAL BOTANIC GARDENS, KEW

XV.—THE STRUCTURE OF SOME SANDALWOODS AND THEIR SUBSTITUTES AND OF SOME OTHER LITTLE KNOWN SCENTED WOODS.

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This account may be regarded as a continuation of a previous paper (17) on the structure of some scented woods from the East. Some additional information has been obtained concerning the structure of the wood of *Cinnamosma fragrans*, which was described in the last paper, as well as of the closely related genus *Warburgia*, and the description of the former given in the previous article needs to be slightly modified in order that the woods of the two genera may be distinguished.

The sandal– and other woods here described are dealt with primarily according to their country of origin. At the present time the chief sources of true sandalwoods, by which are meant oil- and scent-yielding woods belonging to the *Santalaceae*, are India and Australia, whilst some are obtained from Polynesia and New Caledonia (19). Of these, it is generally agreed that East Indian sandalwood, which is the product of *Santalum album*, is the most superior both in the quality of the wood and yield of oil. Australian sandalwood is largely the product of *Eucarya spicata* Sprague et Summerhayes, although other members of the *Santalaceae* have also been used. In India the quite distinct woods *Erythroxylum monogynum* Roxb. and *Ximenia americana* Willd. are sometimes used as substitutes, and *Eremophila Mitchelli* Benth. (*Myoporaceae*) is the source of a bastard sandalwood in Australia. Descriptions of these have therefore been included.

The so-called West Indian or Venezuelan sandalwood of commerce, the oil of which is said to be very inferior to that of *Santalum album*, is believed to be the product of *Amyris balsamifera L.* (*Rutaceae*), the wood structure of which is here described. The botanical source of the sandalwoods of East Africa and Madagascar is somewhat obscure, but it seems evident from the information and specimens collected together during the present investigation that, although there is evidence that the wood of some member or members of the *Santalaceae* may be employed, a proportion is provided by the quite unrelated genus *Brachylaena* of the family *Compositae*. In addition scented woods are obtained from *Cinnamosma fragrans* Bail. and *Warburgia* spp. (*Canellaceae*).

Although they are not commonly known as sandalwoods, brief accounts of the scented woods of *Convolvulus scoparius* (Canary

rosewood) from Teneriffe, and *Urandra* sp. (daru-daru or dedaru) from Singapore have been included.

As is usual when dealing with woods that have been used commercially from ancient times, great difficulty has been experienced in obtaining accurately named specimens. Apart from specimens in the Kew museums, samples of a few of the woods accompanied by herbarium material from the same source have been obtained direct from Australia. Some specimens have been obtained from the collections at the Imperial Forestry Institute, Oxford, and the Forest Products Research Laboratory, Princes Risborough. In addition a large number of specimens were supplied by Prof. S. J. Record from the collections at Yale University, the identity of some of which had been previously authenticated by a study of the corresponding herbarium material. It has thus been possible to make anatomical comparisons of material from a wide range of sources, and to eliminate a number of erroneously named specimens. Where there has been lack of agreement in minor respects amongst different apparently reliable specimens of any particular species, this has been indicated in the text.

The technical terms used in describing the woods are for the most part those which have been defined in the " Glossary of Terms used in Describing Woods " (35) which has recently been compiled by a special committee of the " International Association of Wood Anatomists."

True Sandalwoods from various species of Santalaceae from India, Australia, and Islands in the Pacific.

Sawyer, writing of santal wood in 1892 (3) quotes the following remarks of Dr. Berthold Seeman : " the trade in this fragrant wood has been going on since the dawn of history, and will probably not cease until the connection between santal trees and idolators, existing from time immemorial, shall have been broken up, by either the one or the other becoming as extinct a race as the Archaeopteryx or the Dodo." It is not, therefore, surprising that a great deal should have been written concerning this wood, and it may be a matter for wonder that there is still more to be said concerning it. Nevertheless, an analysis of the literature reveals that it for the most part consists of oft-repeated statements taken from a limited number of original papers written by those with a first hand knowledge of the wood. Probably the most complete early account of the botanical origin of sandalwood was written by E. M. Holmes (10). He gives a list of species of *Santalum* then believed to be the source of various local sandalwoods. The chief of these is *Santalum album*, whilst the remainder are mostly confined to small islands ranging from the Malayan region and Australian coast across the Pacific ocean. Even at the time when Holmes's paper was written it was believed that many of these local sandalwoods were already exterminated owing to rapid exploitation, and

it is stated that substitutes began to come into use for this reason. For instance one reads that owing to the rapid destruction of *S. freycinetianum* Gaud. in the Sandwich islands in 1849 " an attempt was subsequently made to sell the scented wood of *Myoporum sandwichense* A. Gray, in order to revive the trade, but it did not succeed."

At the present time the main source of true sandalwood is still *Santalum album*, which is cultivated in India largely in the region of Mysore. Writing in 1932, Pearson and Brown (19) state that the total production of sandalwood in India may be put at 3,000 tons per annum.

The botanical identity of the trees yielding Australian Sandalwood has been a matter of controversy, (16, 20, 34) but following the reinvestigation of the taxonomy and nomenclature of the family by Sprague and Summerhayes (33) it has become usual to refer to the principal sources as *Eucarya spicata* Sprague et Summerhayes (syn. *Fusanus spicatus* R. Br.) and *E. acuminata* Sprague et Summerhayes (syn. *Fusanus acuminatus* R. Br.). According to Holmes (10) *Exocarpus latifolius* R.Br. yields a little oil less fragrant than that of *S. album*. According to Penfold (20) *Eucarya spicata* yields an oil of very high quality, more especially in recent years when more attention has been paid to selecting suitable wood and to the technique of extraction. Penfold quotes H. V. Marr as having stated that the sandalwood industry of West Australia dates back to 1846 when 4 tons of wood were exported. Of recent years the trade has increased considerably. In 1921, 6800 lbs. of oil were produced, and since then there has been a steady increase, as much as 100,000 lbs. having been produced in 1930. Large quantities of the oil are stated to be exported to America for use in the soap industry. Penfold also mentions that oil is also extracted in Western Australia from *Santalum lanceolatum* R.Br. This oil has been used to a limited extent in order to increase the laevo-rotation of the oil derived from *Eucarya spicata* although its use for this purpose has now been discontinued.

In spite of their having been exploited commercially for so long, there is very little reliable information concerning the wood structure of the different kinds of sandalwood derived from the *Santalaceae*. Petersen (23), working at the University of Strasbourg, carried out an anatomical investigation of various sandalwoods including amongst others *Santalum album*, *S. Yasi* Seem. and *Fusanus acuminatus* R.Br., some of the material having been supplied from Kew. Unfortunately it is quite clear from Petersen's figures and description that the material of *Fusanus acuminatus* R.Br. on which he worked and which came from Kew was really quite a different wood. Moreover, one of the figures illustrating the structure of *Fusanus acuminatus* has been copied in at least one text-book (9). (There is still a specimen in the Kew museum which, until now, has been labelled " *Fusanus acuminatus* R.Br. Paris exhibition 1867."

The structure of this erroneously named specimen agrees closely with the one figured and described by Petersen. It seems that this specimen may have been the cause of the mistake).

A reliable and complete anatomical description of the wood of *Santalum album* is given by Pearson and Brown (19). Some of the measurements, however, given in this description are not sufficiently wide in range, probably because the description was based on only one specimen.

In the present investigation the structure of the following *Santalaceae* has been examined: *Santalum album*, East Indian sandalwood, *S. freycinetianum* Gaud., Hawaiian sandalwood, *S. austro-caledonicum* Vieill., New Caledonian sandalwood, *S. Yasi* Seem., Fiji sandalwood, *Eucarya spicata* and *E. acuminata* Sprague et Summerhayes, which yield Australian sandalwood, and *Exocarpus latifolius* R.Br., also from Australia.

Santalum album (Figs. 1 & 2).

Macroscopic Characters.

Pale brown sap-wood sharply differentiated from the darker but yellowish-brown heart wood. However, since only the heart-wood is strongly scented, most commercial specimens consist only of the heart-wood. *Growth rings* clearly defined in some specimens but less so in others, consisting of zones with relatively crowded pores of large diameter alternating with zones with comparatively few pores of small diameter. *Pores* very small, mostly solitary. *Parenchyma* clearly visible only with the microscope. *Rays* very fine, crowded, not easily visible with a lens.

Microscopic Characters.

Vessels.—Diameter of solitary vessels; radial 20–104 (mostly 48–90)μ, tangential 20–76 (mostly 36–68)μ, average diameters varying considerably in different specimens. 27–61 solitary vessels per sq. mm., almost exclusively solitary but occasionally 2 or even 3 together, disposed radially or tangentially. Some contiguous to rays on one side only, very rarely on both sides. Vessel elements 150–380μ long (mostly 200–300)μ, end walls horizontal or oblique, perforations simple. A few vessels in all specimens plugged with deposits, but the number thus filled varying considerably in different specimens. Pits between vessels and fibres numerous, bordered. Vessel-ray pits rather small, oval to elliptical, horizontally disposed, half-bordered, orifice of larger pits sometimes extending beyond the margin of the pit. *Fibres.*—Groundwork of the wood composed of libriform fibres, not arranged in definite radial rows, somewhat angular, 16–20μ diameter. Individual fibres up to 1,300μ long. Wall of fibres always thick, but in some specimens very much thicker than in others. Radial and tangential walls with numerous

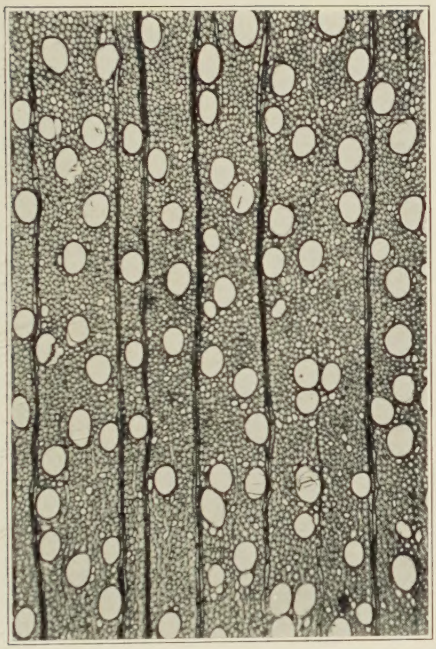

FIG. 1. *Santalum album.*
Transverse section. ×28.

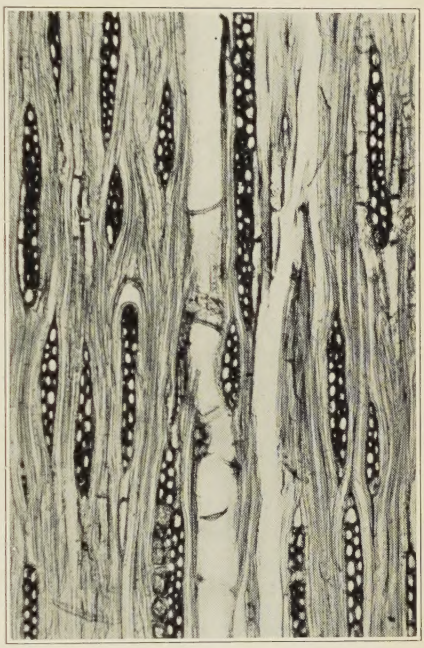

FIG. 2. *Santalum album.*
Tangential section. ×57.

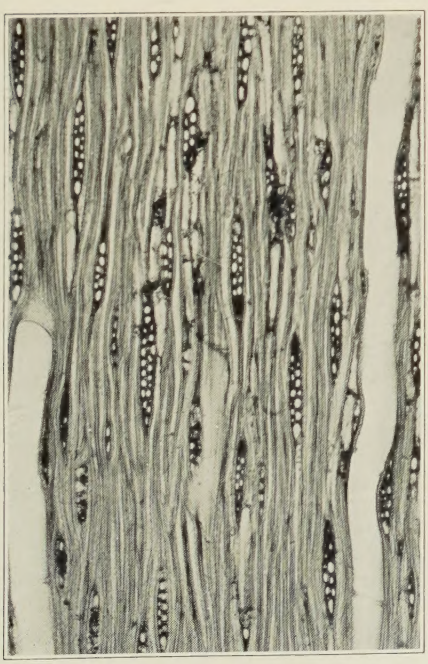

FIG. 3. *Santalum austro-caledoniceum.*
Tangential section. ×57.

FIG. 4. *Santalum Freycinetianum.*
Tangential section. ×57.

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conspicuous bordered pits. *Parenchyma* abundant, chiefly metatracheal, consisting of solitary cells, or chains or groups of 2–5 cells. Diameter of individual metatracheal parenchyma cells 12–28 (mostly remarkably uniform at 16–20μ). Parenchyma chains extending in a radial, tangential, or oblique direction. Paratracheal parenchyma consisting of isolated cells or a few together. Vessels never actually surrounded by parenchyma, but always with some fibres contiguous to them. Parenchyma cells sometimes, but rather infrequently, divided into loculi each of which contains a large solitary crystal, individual chains consisting usually of 2–5 crystals but sometimes as many as 19. *Rays* very fine, 6–10 per mm., uniseriate and biseriate, very rarely partly triseriate (Yale 13659), 1–34 (mostly 10–18) cells high, heterogeneous. Upright cells almost exclusively at margins, usually in one row but sometimes more. Rays mostly 160–360μ high (maximum 580μ) and 8–36 (mostly 16–30)μ wide. Individual cells 12–48μ high, most with brown oily contents.

Material examined:—(1) Kew 67–1929. (2) Yale 19468, 19836, 13659. (3) Imperial Forestry Institute 603. (4) Gamble's 321, and D.3999, and Gamble no number. (In Kew museums).
(Two of the above specimens i.e. 67–1929 and Gamble no number, had rays which were rather shorter than appears to be normal for *Santalum album*. However the remaining 6 specimens examined all conformed to the above description, and it seems probable that this represents the normal structure of *S. album* from India).

No reliable macroscopic characters have been found whereby it is possible to distinguish the wood of *Santalum album* from the various local sandalwoods belonging to the same genus. Nor do the microscopical differences between the genera *Santalum* and *Eucarya*, as represented by the species here described, appear to be more clearly defined than those existing between the various species within the genus *Santalum*. In fact the wood structure of all the *Santalaceae* examined is remarkably similar. Microscopical differences in structure, however, do exist, and these are generally sufficient for a reasonably accurate identification of any commercial specimen of the two genera. It is comparatively easy to identify *S. album* itself on account of its taller rays, and the structure of *Eucarya spicata* cannot readily be confused with that of S. *album*. Since these two species yield most of the sandalwood of commerce this distinction is an important one. If, however, the source of a given sandalwood is known its identification is considerably simplified.

Table I (p. 170) shows the more important measurable characters by which the species may be distinguished. Since the microscopic structure is so similar, no detailed descriptions of the individual species have been drawn up, thus avoiding repetition. Brief notes on the most useful diagnostic characters are given, and it is thought that these, taken in conjunction with the table and illustrations, will be the best guide for identification. The most useful

Species.	Vessels per sq. mm.	Radial vessels diameters.	Tangential vessel diameters.	Rays per mm.	No. of cells in ray height.	Height of rays in μ	Width of rays in μ	Height of ray cells in μ	Diameter of metatracheal parenchyma cells.
Santalum album	27-61	20-104μ mostly 48-90	20-76μ mostly 36-68	6-10	1-34 mostly 10-18	mostly 160-360 maximum 580	8-36 mostly 16-30	12-48	12-28μ
,, freycinetianum	23-55	24-120μ mostly 40-88	28-100μ mostly 40-80	6-10	1-27 mostly 6-16	mostly 100-250 maximum 400	16-40 mostly 20-36	12-40 mostly 20-30	12-40μ mostly 16-32
,, austro-caledonicum	33-76	24-104μ mostly 40-80	30-84μ mostly 40-70	3-9	1-16 mostly 5-11	mostly 100-200 maximum 260	12-28 mostly 20	12-24 v. rarely 40	12-24μ
,, Yasi	37-43	28-112μ mostly 40-90	40-80μ mostly 50-80	7-10	1-13 mostly 6-13	mostly 80-180 maximum 196	16-28	12-40 mostly 12-20	16-32μ rarely exceeding 24
Eucarya spicata	48-95	48-88μ mostly 60-80	40-68μ mostly 40-60	5-8	1-20 mostly 6-13	mostly 100-230 maximum 280	16-36 mostly 16-28	8-64 mostly 12-24	12-28μ mostly 16-24
,, acuminata (1 spec.)	22-31	72-100μ mostly 76-100	60-88μ mostly 64-80	5-8	1-14 mostly 5-10	mostly 100-200 maximum 232	mostly 20-28	12-44 mostly 16-24	12-24μ mostly about 16
Exocarpus latifolius	26-66	68-112μ mostly 80-100	60-92μ mostly 60-80	3-11	1-16 mostly 7-9	mostly 80-180 maximum 320	12-28 mostly 12-20	12-36 mostly 12-36	12-32μ mostly 16-24

Table I.—In the above table the low figures given in each case do not represent the smallest observed, but the smallest that were at all frequent.

single character by which the species of *Santalum* may be distinguished is the height of the rays. Reference to table I shows that the species *S. album*, *S. freycinetianum*, *S. austro-caledonicum* and *S. Yasi* form a series in this order with progressively shorter rays. However, the ray height in the Australian Eucaryas and *Exocarpus latifolius* rather overlaps with that of some of the species of *Santalum*, so that it is not possible to place all the *Santalaceae* investigated in a regular order on the basis of this character alone.

The only other outstanding features of diagnostic value are:—(1) that in most specimens of *Santalum freycinetianum* there are narrow, practically continuous, concentric zones of (terminal) parenchyma: these were not observed in any specimen in any other species: (2) that in *Eucarya spicata* the vessels are much more frequently in groups than in any other of the *Santalaceae* examined: Moreover, the obliquely arranged groups (transverse section) often consist of three, four, or more rarely, five vessels.

S. austro-caledonicum *Vieill.* New Caledonian Sandalwood. (Fig. 3).

Growth rings often more clearly defined than in the other *Santalaceae* except *Eucarya spicata*; boundaries marked by comparatively broad zones with very few vessels of small diameter. *Fibres* rather wider than in most species, 20–24μ diameter. Two rows of bordered pits frequently visible in the width of a fibre (longitudinal section). *Metatracheal parenchyma* in most specimens tending to be in comparatively long tangential or oblique rows, sometimes consisting of as many as 8 or more cells. (This was not true of Yale 13991). *Rays* 1–16 (mostly 5–11) cells high. Actual height of rays mostly 100–200 (maximum 260)μ. Individual ray cells 12–24 (very rarely 40)μ high. *Crystals* in chains of 3–15 (in some specimens as many as 24). Crystal rows occasionally partly biseriate. Crystal-containing cells 12–40 (mostly 2–28)μ high.

Material examined:—(1) Kew 1930. (2) Yale 13991, 14249, 14316.

Santalum freycinetianum *Gaud.* Hawaiian Sandalwood. (Fig. 4).

Vessels.—Radial diameter 24–120 (mostly 40–88)μ, tangential diameter 28–100 (mostly 40–80)μ. *Fibres.*—Lumen of fibres wide compared with *S. album*, and, as in *S. austro-caledonicum*, two rows of bordered pits frequently visible in the width of a fibre (longitudinal section). *Parenchyma.*—Most specimens clearly differentiated from other species of *Santalum* by the presence of more or less continuous concentric bands of (terminal) parenchyma (not observed in one specimen). *Rays* 1–27 (mostly 6–16) cells high. Height mostly 100–250 (maximum 400)μ. *Crystals* in chains of 2–26, but number very variable in different specimens. Crystal-containing cells 24–44 (mostly 30–40)μ high.

Material examined:— (1) Kew 29–1891. (2) Yale 1903, 1904, 21221. (3) Authentic material from Hawaii, received 1934.

Santalum Yasi *Seem.* Fiji Sandalwood. (Fig. 5).

Vessels.—Radial diameter 28–112 (mostly 40–90)μ ; tangential diameter 40–80 (mostly 50–80)μ. *Fibres* with narrow lumen as in *S. album*, or sometimes even narrower. Usually only one row of bordered pits visible in the width of a fibre (longitudinal section). *Parenchyma.*—Diameter of metatracheal parenchyma cells 16–32 (rarely exceeding 24)μ. *Rays* very short, 1–13 (mostly 6–13) cells high ; height 80–180 (maximum 196)μ. *Crystals* usually in chains of 3–9.

Material examined :—(1) Kew 1879. (2) Imperial Forestry Institute 2913.

Eucarya spicata *Sprague et Summerhayes.* Australian Sandalwood. (Fig. 6).

Growth rings well defined, especially in comparatively small branches. In older wood marked by narrow concentric bands in which the fibres are arranged in radial rows. *Vessels.*—48–95 per sq. mm., in some specimens more frequent than in any other of the *Santalaceae* examined ; more frequently in pairs or groups than in any species of *Santalum*. Obliquely arranged pairs very frequent, and sometimes present in oblique groups of 3, 4, or more rarely 5. Tangential and radial pairs fairly frequent. Radial groups of three occasional. Vessel walls often flattened where in contact with one another. *Fibres* short, with 1 or 2 rows of bordered pits in the width of a fibre (longitudinal section). Pitting similar to that in *Santalum freycinetianum*. *Rays* 1–20 (mostly 6–13) cells high, mostly 100–230 (maximum 280)μ high. Ray cells sometimes 64μ high (taller than in any other of the *Santalaceae* examined), but mostly included in the range 12–24μ high. *Crystals* in chains of 2–10 (seldom more than 7). Crystal-containing cells larger than in any of the other *Santalaceae*, 24–80μ high.

Material examined:—(1) Kew 130–1885. (2) Woods and Forests, specimen received in 1933.

Eucarya acuminata *Sprague et Summerhayes.* South Australian Sandalwood.

Vessels.—Radial diameter 72–100 (mostly 76–100)μ ; tangential diameter 60–88 (mostly 64–80)μ ; 22–31 per sq. mm. (Less frequent than in any of the other Santalaceae examined. It is, however, questionable whether much reliance should be placed on this character since only one authentic specimen was examined) ; rarely in pairs. *Fibres* with similar structure and pitting to *E. spicata*. *Rays* 1–14 (mostly 5–10) cells high ; height 100–200 (maximum 232)μ. *Crystals* in rather infrequent chains of 3–6. Crystal-containing cells 24–60 (mostly 24–44)μ high.

Material examined:—(1) Kew 1863. (2) Forestry Commission N.S. Wales, specimen received in 1933.

FIG. 5. *Santalum Yasi*.
Tangential section. × 57.

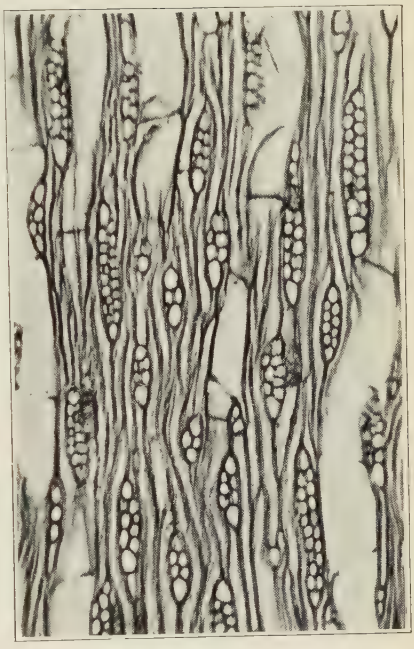

FIG. 6. *Eucarya spicata*.
Tangential section. × 57.

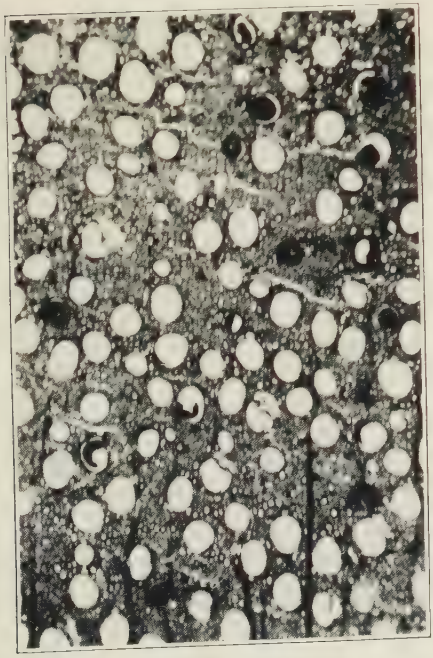

FIG. 7. *Exocarpus latifolius*.
Transverse section. × 28.

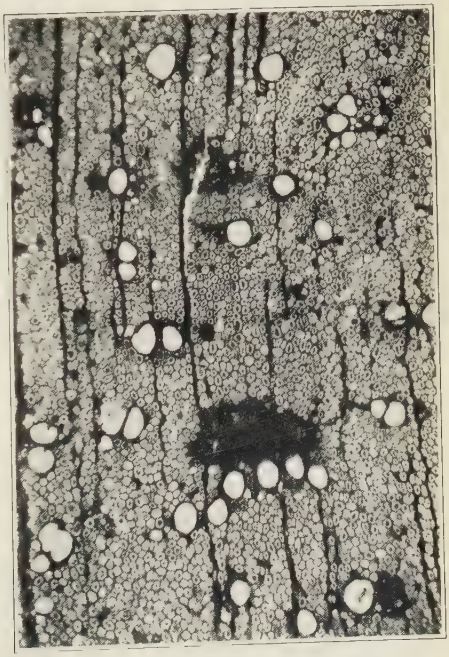

FIG. 8. *Convolvulus scoparius*.
Transverse section. × 28.

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Exocarpus latifolius *R.Br.* (Fig. 7).

Although no reliable macroscopical method of distinguishing the individual species of *Santalum* and *Eucarya* has been found, the general appearance of the wood of *Exocarpus latifolius* is rather more distinct. In the one large specimen available there was no clear differentiation into heart and sap wood. The wood was darker in colour than is usual in *Santalum* and *Eucarya*, and the yellowness characteristic of the true sandalwoods was absent. Rather infrequent, narrow, concentric lines (transverse surface) of wood very much darker in colour than the remainder. These appeared as dark streaks on longitudinal surfaces. *Vessels*.—Radial diameter 68–112 (mostly 80–100)μ ; tangential diameter 60–92 (mostly 60–80)μ ; almost exclusively solitary, rarely in tangential or oblique pairs. *Fibres* with very thick walls, lumen in some almost obliterated, walls thicker than those of the two species of *Eucarya* examined. *Metatracheal parenchyma* cells abundant, thin-walled, many filled with densely staining contents, standing out in marked contrast to the groundwork of thick-walled fibres. *Rays* 1–16 (mostly 7–9) cells high ; height mostly 80–180 (maximum 320)μ. *Crystals* usually present in chains of 3–17, but somewhat variable in individual specimens. Crystal-containing cells 16–40 (mostly 20–32)μ high.

Material examined:—(1) Kew 1862. (2) Yale 5314.

Aqueous and Alcoholic Extracts of Santalum, Eucarya and Exocarpus.

Aqueous and alcoholic extracts of these woods are usually almost colourless or slightly lemon coloured, whilst others are reddish brown. If dilute ammonia (10 per cent. of ·880) be added to any of them the colour is invariably intensified. These colour reactions can to some extent be used as confirmatory identification tests, although it would be very unwise to rely on these tests alone, as the results obtained are not always consistent. The colours most usually obtained on adding ammonia to extracts of the woods are as follows :—

S. album—reddish brown or pale ale coloured. Sometimes slightly fluorescent.

S. freycinetianum—colour as in *S. album* but frequently more intense. Slightly fluorescent.

S. Yasi and *S. austro-caledonicum*—Pale lemon coloured, sometimes with a faint green tinge.

Eucarya spicata, *E. acuminata*, and *Exocarpus latifolius*—Similar to *S. Yasi* and *S. caledonicum*, but in every instance in which tests were made, the colour was more intense, having the appearance of clear lemonade.

Substitutes for True Sandalwoods.

Eremophila Mitchelli *Benth.* (*Myoporaceae*). Budda or Bastard Australian Sandalwood. (Figs. 9 and 10).

In the paper by Holmes to which reference has already been made (10), it is stated that *Eremophila Mitchelli* is the source of a sandalwood from Queensland. Recently the oil derived from this tree (known vernacularly as budda wood, bastard sandalwood, or budtha) has been examined by Bradfield, Penfold and Simonsen (3). The oil is stated to be rather dark, and although unsuitable to replace sandalwood oil for all purposes, it is said to have " remarkable qualities which place its value in line with those of fixative balsams. It has not a strong odour, but is soft with a suggestion of geranium to bergamot backing."

On the labels on some specimens of this wood kindly supplied from the Technological Museum at Sydney by Mr. Penfold, the following particulars of the wood and tree are given : " a pale yellowish-brown, close textured, rather greasy, aromatic timber with lighter coloured streaks running through it. The medullary rays are very small and numerous, the growth rings giving the timber figure. Although hard, it is an easy timber to work, and polishes well. Suitable for small cabinet work and panelling, veneers, turnery, fancy boxes, brush backs and similar ornamental purposes. A medium sized tree of 50–60 feet, fairly plentiful in some localities, found in the interior of Queensland, New South Wales, and S. Australia. Weight about 68 lbs. per cubic foot."

The following is an account of the microscopical characters of the wood based on two specimens, one of which was accompanied by the corresponding herbarium material, obtained from the Technological Museum at Sydney. Later on a similar authentic specimen was received from the Forestry Commission, N.S. Wales.

Microscopical Characters.

Growth rings numerous, fairly well defined, boundaries marked by narrow concentric zones in which the vessels with relatively small diameters tend to be in smaller irregular clusters and less frequently in radial chains than elsewhere. A large proportion of the vessels in these zones filled with contents or tyloses. (In sap wood vessels without contents and tyloses). *Vessels* almost all in irregularly shaped groups or clusters ; scarcely any solitary ones observed. Shape of the groups or clusters in different parts even of a single specimen very variable. In some parts of most specimens vessels predominantly in long radial rows, sometimes consisting of as many as 36 contiguous vessels. 20–40 (mostly 25–36) vessel groups per sq. mm. In many instances the individual groups not clearly defined owing to coalescence of adjacent groups. Vessel groups frequently contiguous to rays on at least one side. Solitary vessels so infrequent that none were measured. Radial diameter of individual vessels in groups 28–80 (mostly 40–70)μ ; tangential diameter 28–80 (mostly 40–60)μ, but in sap wood tangential diameter

most frequently 60–80μ. Vessel elements 140–260μ long, end walls nearly all horizontal, perforations simple. Intervascular pits minute, crowded, sometimes coalescing, chiefly in approximately horizontal rows. Vessel-ray pits most easily seen in sap wood, (obscure in heart wood owing to the presence of deposits), where visible apparently similar to intervascular pits. *Fibres.*—Groundwork of wood composed of very thick-walled, irregularly arranged fibres, shape variable in transverse section, 0·45–0·85 mm. long; ends usually tapering to a fine point, lumen widest in the middle of the fibres. Pits few, not very clearly visible, apparently simple. *Parenchyma* chiefly paratracheal, mostly consisting of a few isolated cells around the vessels, but never entirely surrounding them; especially well developed in association with the irregular shaped vessel groups, in some instances occupying all the space between small groups of vessels which together form a larger aggregate of vessels. (In order to make this clearer it may be mentioned that some of the irregular shaped groups of vessels are in a sense compound since they consist of 2 or 3 smaller groups which are almost contiguous, but separated from one another only by a single layer of parenchyma cells). Most parenchyma cells usually filled with densely staining contents (except in the sap wood). *Rays* 8–15 per mm. very variable in structure, many wholly uniseriate, some partly or wholly bi- or tri-seriate, others bi- or tri-seriate at the centre (tangential section) but with long uniseriate margins on one or both sides. Heterogeneous, marginal and uniseriate portions of rays usually consisting of upright cells. Rays 1–23 (mostly 3–20) cells high; height very variable even in different parts of a single specimen, but majority included in the range 150–450 (maximum observed 725)μ; width 12–40μ; ray cells 16–40μ high, 8–32μ wide, mostly filled with densely staining contents. (In sap wood contents less frequent, and where present, not staining so deeply). Large solitary crystals of various shapes present in some of the ray cells.

Material examined:—(1) Technological museum Sydney. Two specimens received in 1934. (2) Forestry Commission N.S. Wales. Specimen received in 1934.

Ximenia americana *Willd.* (*Olacaceae*). (Fig. 11).

According to several authorities the wood of this tree is used in India as a substitute for that of *Santalum album* (7, 18, 29). The Brahmins, especially, use it in their religious ceremonies. According to Record (l.c.) *X. americana* is the best known and most widely distributed member of its genus. It sometimes grows to a tree 30 feet high, but it is more often a shrub, occurring in tropical- and sub-tropical regions throughout the world. It is known sometimes in S. America as " false sandalwood " or " yellow sanders."

In general appearance and structure the wood of this species has many points in common with that of the *Santalaceae*. This will be made clear if the following description is compared with that of *Santalum album*.

Macroscopic Characters.

Wood yellow to light brown. Most of the specimens too small to determine whether heart and sap wood are well differentiated, but in specimen Kew 79–1886 the comparatively narrow sapwood was clearly differentiated from the darker coloured heart wood. *Pores* small, usually evenly distributed, solitary. *Growth rings* not very clear in some specimens, but clearer in others, boundaries marked by a few smaller vessels. (In specimen 79–1886 collected by J. S. Gamble, growth rings more clearly defined, wide concentric bands with relatively infrequent vessels being present). *Rays* very fine, crowded, visible with lens.

Microscopic Characters.

Vessels nearly all solitary but sometimes in radial, tangential or oblique pairs, occasional tangential groups of four. Radial diameter of solitary vessels 40–120 (mostly 60–100)μ ; tangential diameter 32–88 (mostly 40–80)μ. For the most part evenly distributed, except for boundaries of growth rings (and in the zones of varying frequency in specimen (79–1886). 19–53 solitary vessels per sq. mm., but relatively constant throughout a single specimen. Vessels elements short, 160–400 (mostly 200–300)μ long, end walls mostly horizontal, perforations simple. Deposits and tyloses abundant in specimen 79–1886, tyloses common and deposits scarce in Yale 20509, and both deposits and tyloses scarce in Imperial Forestry Institute 2392. Vessel-ray pits half bordered, somewhat elongated, up to about 16u wide in broadest diameter. *Fibres* lumen widest in the middle, ends tapering. Length 0·7–1·4 mm., thick-walled. Pits rather large and fairly numerous, bordered. *Parenchyma.*—Very little present, chiefly metatracheal, consisting of single isolated cells scattered amongst the fibres, but sometimes 2 or 3 cells together in oblique or radial rows (transverse section). Most parenchyma cells filled with deposits. A few, usually isolated, paratracheal parenchyma cells also present. *Rays* 9–14 per mm. Uni- or bi-seriate, very rarely partly tri-seriate. 1–19 (mostly 5–8) cells high. The rays in Yale 20509 mostly higher than those in Gamble's specimen 79–1886. Heterogeneous. Uniseriate rays nearly always consisting entirely of upright cells, whilst the broader rays consist chiefly of procumbent cells with upright ones intermixed. Tall cells more frequent in Yale 20509 than in Gamble 79–1886. Solitary crystals sometimes present in the ray cells. Most ray cells with contents, 9–52μ high.

Material examined:—(1) Kew 79–1886. (2) Imperial Forestry Institute 2392. (3) Yale 20509, 20514.

Extracts.

Aqueous and alcoholic extracts very faint yellowish brown or almost colourless. Scent when boiled in water, faint, peppery ; not very distinctive.

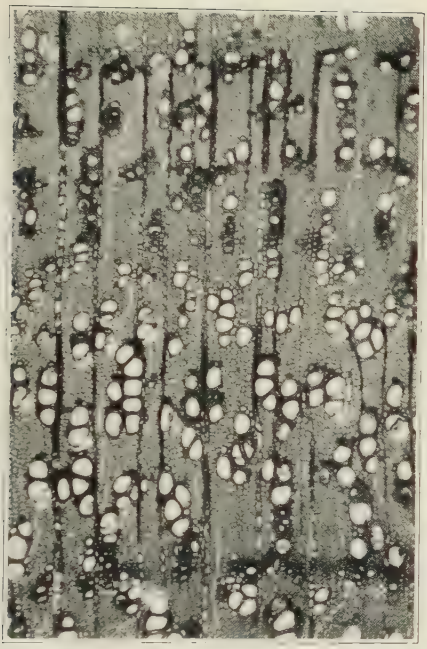

FIG. 9. *Eremophila Mitchelli*.
Transverse section. × 28.

FIG 10. *Eremophila Mitchelli*.
Tangential section. × 57.

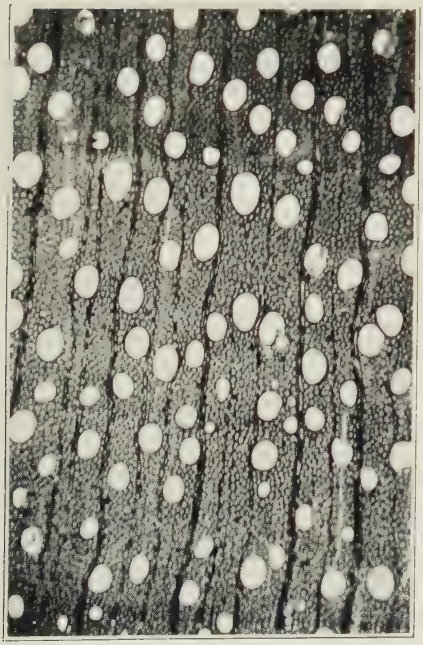

FIG. 11. *Ximenia americana*.
Transverse section. × 28.

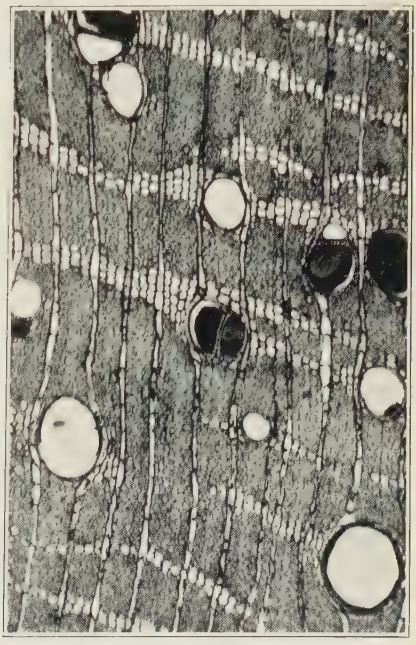

FIG. 12. *Pterocarpus santalinus*.
Transverse section. × 28.

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The similarity in the wood structure of *Ximenia* and *Santalum* is of taxonomic interest. *Ximenia*, of the family *Olacaceae*, was placed by Bentham and Hooker (1), together with the *Ilicineae*, in the *Olacales*, which were regarded as being widely separated from the *Santalaceae*. Engler and Gilg (6) on the other hand classify the *Olacaceae* together with the *Loranthaceae* and *Santalaceae* in the same order, the *Santalales*. Hutchinson (12) differs from Engler and Gilg in placing the *Olacaceae* and *Santalaceae* in the separate orders, *Olacales* and *Santalales* respectively, but he regards many of the *Santalales* as reduced parasitic forms of the closely related *Olacales*. The similarity of the wood structure of *Ximenia americana* and *Santalum album*, supports the classification of Engler and Hutchinson, rather than that of Bentham and Hooker.

Comparison of the wood of *Ximenia americana* with that of *Santalum album* shows that the former can be distinguished most easily by the following characters of the medullary rays :—
1. The rays are shorter. 2. The broader rays are more markedly heterogeneous, and the upright cells are fairly frequent in the middle of the rays as well as at the margins. 3. The frequent occurrence of uniseriate rays composed only of upright cells. 4. The vessel-ray pits are frequently much larger and less numerous.

Erythroxylum monogynum *Roxb.* (*Erythroxylaceae*).

In a letter from H. SenGupta (31) it is stated that this wood is used as a substitute for *Santalum album* especially in South India where it often grows in the same habitat. It is used especially to adulterate sandal paste. A detailed description of the anatomy of this species has not been made owing to lack of authentic material. Moreover such reliable specimens as were available differed from one another in certain minor respects, which indicated that all the specimens may not belong to the same species. However, the specimens agreed in structure sufficiently to make it probable that they at least belonged to the same genus. The main anatomical features which were common to these specimens, and by means of which they may readily be distinguished from the other species described in this paper, are as follows :—

Macroscopic Characters.

In general the macroscopic appearance of the wood agrees with the brief description given by Gamble (8). The wood is very hard ; the heart and sap wood are clearly differentiated, the former being dark reddish brown, and the latter very pale brown. The specimens did not emit any scent, but this may have been due to their having been stored for some years. Gamble, l.c., describes the wood as having a pleasant resinous smell. *Pores* very small, but individually distinct with a lens, numerous, often in radial groups (more clearly seen with the microscope). *Rays* very fine, crowded, but usually clearly visible with a lens.

Microscopical Characters.

Growth rings not very obvious in most specimens, but where present (especially in Imp. For. Inst. 237) boundaries marked by tangential bands of rather large fibres, very definitely rectangular, many with lumen considerably broader than those elsewhere ; in some instances accompanied by a single, more or less regular, tangential row of solitary vessels. *Vessels.*—Diameter of solitary vessels variable in different specimens, mostly 60–90 (maximum 116)μ radial and 50–80 (maximum 100)μ tangential ; solitary (especially in Kew 1878) or in radial groups of as many as 8, but usually less than this number ; infrequently in irregular clusters. Individual vessels of a chain with flattened walls where in contact with one another, 26–52 vessels or groups per sq. mm. In specimens with the higher numbers per sq. mm. the proportion of solitary vessels much greater. Perforations simple, end walls horizontal or slightly oblique. Intervascular pits minute, bordered, very numerous but not crowded. Pits in some specimens circular with circular apertures, but in others horizontally oval with slit-like apertures. Deposits in vessels fairly frequent. *Fibres.*—Groundwork of wood composed of libriform fibres, mostly in radial rows, but locally becoming irregular. Some fibres rounded in cross section, but others angular, but always markedly rectangular at boundaries of growth rings where these are present. Pits rather variable in different specimens. *Parenchyma.*—Paratracheal parenchyma fairly frequent, consisting of a few cells, isolated or contiguous to one another, adjoining but never completely surrounding the vessels. Metatracheal parenchyma abundant, consisting of solitary cells, or short chains which extend in various directions amongst the fibres, sometimes connecting adjacent vessels or vessel groups. Length and frequency of the chains varying in different specimens. Frequent vertical columns of parenchyma cells (up to 32 cells high), each containing a solitary crystal. Nearly all parenchyma cells filled with contents. *Rays* characteristic of the specimens taken as a whole, but varying somewhat in the individual specimens. In Yale 3816 and Imperial Forestry Institute 237 mostly biseriate, in Kew 1878 mostly triseriate, but in all specimens frequently provided with long, uniseriate, tail-like endings. Wholly uniseriate rays also observed. Markedly heterogeneous, up to 24 (mostly 12–20) cells high, but sometimes appearing taller on account of the fusion of 2 rays.

Material examined :—(1) Kew 1878. (2) Yale 3816. (3) Imperial Forestry Institute 237.

Extracts.

Aqueous extracts almost colourless, but with faint reddish-brown tinge, turning yellowish on adding ammonia. Alcoholic extracts even less coloured than aqueous ones.

Pterocarpus santalinus *Linn.f.* (*Leguminosae*). Red Sanders Wood. (Fig. 12).

The wood of *Pterocarpus santalinus* has sometimes been referred to as red sandalwood, but it may at once be distinguished from the true sandalwoods by the dark red heartwood which was at one time much employed as the source of a dye. Large quantities were shipped from Madras to Europe, but it is now used in this way only to a limited extent.

According to Gamble (8) *Pterocarpus santalinus* is a small or moderate sized tree. Wood extremely hard; sapwood white, heartwood dark claret-red to almost black, but always with a deep red tinge, orange-red when fresh cut.

Macroscopic Characters.

Growth rings.—None clearly defined in the specimens examined. *Vessels* individually distinct with a lens. Rather irregularly distributed, mostly solitary, embedded in narrow tangential bands of parenchyma, very often with contents (sometimes white). Vessel lines appearing as distinct scratches, darker in colour than the surrounding wood on account of the dark coloured contents. *Parenchyma* abundant, chiefly as sinuous, concentric lines, somewhat lighter in colour than the surrounding wood, extending from (and in some places connecting) the vessels. Extending tangentially from other vessels only for short distances. *Rays* very fine, and crowded, only just visible with a lens on transverse and tangential surfaces, somewhat more obvious on radial surfaces. *Ripple Marks* distinct in some specimens.

Microscopic Characters.

Growth rings not distinct, although in a few instances concentric zones of relatively thick-walled fibres contiguous to relatively thin-walled ones. Terminal parenchyma sometimes present. *Vessels*.—Radial diameter 88–280 (mostly 100–220)μ; tangential diameter 84–200μ rather irregularly distributed, 2–9 (mostly 3–5) vessels or vessel groups per sq. mm. Vessels mostly solitary or in radial groups of 2–3; sometimes obliquely arranged, and rarely in irregular clusters of up to 9 vessels; frequently filled with deposits. Vessel elements very short, 150–310μ long, end walls mostly horizontal, with simple perforations. Intervascular pits mostly in horizontal rows, circular or oval, crowded; aperture elongate-oval or slit-like, with long axis horizontal, vestured, extending almost to the outside of the borders. Vessel-parenchyma and vessel-ray pits half-bordered. *Fibres*.—Groundwork of wood composed of libriform fibres, 550–1,100 (mostly 700–1,000)μ long, with tapering ends; lumen narrow (except in some fibres which were very broad in the middle), mostly filled with contents. Pits very infrequent, simple, circular-oval. Fibres tending to be in radial rows, but not regularly

so. *Parenchyma* abundant, chiefly paratracheal, but with tangential extensions, which in some places connect separate vessels or vessel groups. Tangential extensions very short in some instances (aliform parenchyma). Concentric parenchyma bands in some places independent of the vessels, 1–4 (or occasionally more) cells wide. Cells abundantly pitted, storied, mostly in pairs with gabled ends, 100–112μ long, radial diameter mostly 20–30μ. Some cells divided into chambers, each containing a solitary crystal. A few isolated chains of parenchyma cells also present amongst the fibres, each cell in most instances containing a single large crystal. A few narrow bands of terminal parenchyma present. *Rays* 6–11 per mm., often deviating to pass round a vessel ; mostly uniseriate, but also partly or wholly bi- or tri-seriate. Biseriate rays more frequent in some specimens than in others. Storied, up to 9 (mostly 6–7) cells high ; Rays 108–136μ high, but sometimes exceeding this. Tallest ray observed 180μ high. Cells mostly 20–24μ broad and 20–32μ high.

Material examined :—(1) Imperial Forestry Institute 4655. (2) Yale 3855. (3) Kew 1928.

Extracts.

Aqueous extracts of shavings of the heartwood are yellowish in colour, and a red scum forms on the surface of the liquid. If dilute ammonia is added to an aqueous extract the liquid turns yellowish-brown and fluoresces blue-green. If dilute hydrochloric acid is added the liquid tends to become discoloured. An alcoholic extract is yellowish-red even when cold, but, if warmed, it becomes a characteristic, intense deep red colour. If shavings are boiled in water an extremely pleasant smell, very similar to that of *Warburgia* and *Cinnamosma*, is emitted.

Adenanthera pavonina *L.* (*Leguminosae*).

The wood of this species, which is used chiefly for house building and cabinet making, has been included in the present paper on account of the statement of Watt (36) that it is sometimes used as the source of a dye, and also as a substitute for true red sandalwood (*Pterocarpus santalinus*). It is also known as red-wood or coral-wood. Watt also states (37) that the vernacular name rakta-chandan, which truely refers to *Pterocarpus santalinus*, is sometimes erroneously applied to *Adenanthera pavonina*. During the present investigation aqueous and alcoholic extracts of shavings of 3 samples of *A. pavonina* wood were prepared and found to be almost colourless or at most very pale brown. This serves as a ready means whereby it may be distinguished from *P. santalinus*. Whether *A. pavonina* is at present used as a substitute for *P. santalinus* on any considerable scale has not been definitely determined. Mr. C. E. C. Fischer tells me that although familiar with districts in India in which *P. santalinus* is grown, he has never heard that *A. pavonina*, (which

he has seen only in cultivation), is used as a substitute in this way. He suggests, however, that *A. pavonina* may be used as a substitute in other districts where it is more plentiful and where *P. santalinus* is not readily available.

A long detailed account of the wood structure of *A. microsperma* is given by Janssonius (13). The structure of *A. pavonina*, which is stated by Janssonius to be very similar to that of *A. microsperma*, is also given but more briefly. The different specimens available for examination during the present investigation varied somewhat, and since herbarium material corresponding to the wood specimens was not available it was not possible to check their identities. However, it seems probable that all the specimens were closely related if not identical, and the following description embraces the characters of all of them.

Macroscopic Characters.

Different samples of wood varying considerably in colour and texture. Colour ranging from dark brown (almost black) to light brown, reddish, or yellowish brown. *Rays* scarcely perceptible with the naked eye. *Pores* distinct, solitary, or in short radial chains, mostly evenly distributed, but some specimens with tangential bands with very few vessels in them. Pores sometimes plugged with white or dark coloured contents. All vessels surrounded by clearly defined parenchyma, lighter in colour than the groundwork of the wood. *Growth rings* present, but more clearly defined in some specimens than in others. *Parenchyma* extending tangentially for short distances from some of the pores, and rarely in continuous tangential bands (terminal parenchyma).

Microscopic Characters.

Vessels solitary or in groups, those in groups usually radially arranged ; 2–6 (mostly 3–4) vessels or groups per sq. mm. Vessel groups consisting of 3–14 individual vessels, but varying considerably in different specimens. (In Kew 67–1929 only 2–5 in a group). Radial diameter of solitary vessels 170–300μ, tangential diameter 120–200μ. Individual vessels of groups smaller than the solitary ones 50–200μ radial and 80–200μ tangential diameter. Perforations simple, end walls horizontal or oblique. Vessel elements varying in length in different specimens, ranging from 160–600μ. Intervascular pits bordered with slit-like apertures, sometimes compound. Vessel-parenchyma and vessel-ray pits of the same type, difficult to see in some instances owing to the presence of a brown substance partly or wholly plugging the vessels. *Parenchyma.*—Para- and metatracheal parenchyma present. (Terminal parenchyma in 13–1924). Paratracheal parenchyma several layers thick, completely surrounding the solitary vessels or vessel groups. Sometimes extending tangentially for short distances. Usually only one vessel or vessel group included within a single mass of paratracheal parenchyma, but in a few instances separate vessel groups united by

paratracheal parenchyma. A large proportion of paratracheal parenchyma cells usually filled with deposits (especially in heart wood). Radial diameter 20–32μ, tangential diameter 20–64μ. Length 80–180μ. Metatracheal parenchyma cells often with contents, usually slightly smaller than the paratracheal ones. *Fibres.*—Groundwork of wood composed of libriform fibres in radial rows, and provided with minute pits. Mostly polygonal, with thick walls and circular or elliptical lumen, 12–28μ diameter, lumen up to 12μ. Some fibres replaced by longitudinal series of crystal containing cells, each cell containing a single crystal, 8–36 in a single series, but the lengths of the series varying in different specimens. Some chains of crystal cells rarely biseriate for a short distance. Walls usually thin, cells cubical, but in some specimens with thicker walls especially in heartwood. In some instances attached to the margins of the rays. Cells at the ends of the rows often smaller than those in the middle, or, on the other hand, individual rows composed of small or large cells throughout. *Rays* 4–9 per mm., uniseriate or partly or wholly biseriate, very rarely triseriate, 2–20 (mostly 6–16) cells high; homogeneous. Cells 16–40μ high, nearly all with contents, but in some specimens contents scarce.

Material examined :—(1) Kew 67–1929. (2) Imperial Forestry Institute 1996. (3) Yale 880.

(Kew 13–1924, sent from Singapore by Mr. Burkill, differs somewhat from the above, but most notably in having concentric (terminal) parenchyma).

Extracts.

Aqueous and alcoholic extracts almost colourless or very pale brown. No distinctive scent given off when boiled.

Amyris Balsamifera *L.* (*Rutaceae*). West Indian Sandalwood. (Figs. 13 and 14).

In 1886 E. M. Holmes (10) writing on sandalwoods, stated that he believed only two were then in use commercially. These were the woods of true sandalwood (*Santalum album*) and Venezuelan sandalwood. The identity of this last was uncertain, but having obtained incomplete herbarium material from the tree yielding the oil, Holmes suggested that it might belong to the *Rutaceae*. Shortly afterwards Kirby (15), working with material supplied by Holmes, made an anatomical investigation of the leaf structure, and, on rather insufficient evidence, concluded, like Holmes, that the tree might belong to that family. By 1899 Holmes (11) had obtained herbarium specimens that were more complete and described the plant as a new species of *Rutaceae* under the name *Schimmelia oleifera*. According to a later article (26) portions of Holmes' specimens were examined at Berlin by Urban who recognised it as being identical with *Amyris balsamifera* L. which by German botanists was referred to the *Rutaceae*. The fact of its being identical

with *A. balsamifera* was overlooked by Holmes (who was then working at Kew) because the genus *Amyris* was placed by Bentham and Hooker in the " Genera Plantarum " amongst the *Burseraceae*. During the present investigation Dr. Sprague pointed out to me that the genus *Amyris* has been placed by Engler (5) in the *Rutaceae-Toddalicae*, next *Teclea*. In Dr. Sprague's opinion, Engler's verdict may be accepted. Further, as will be shown later on, the wood structure of *Amyris balsamifera*, in at least one important particular, agrees with the *Rutaceae* rather than with the *Burseraceae*. An early illustrated account of the wood structure was given by Petersen (23), though at that time its botanical identity was unknown.

In 1914 a note was published (28) stating that the oil derived from *A. balsamifera* had then recently been used as a substitute for and in order to adulterate the oil of *Santalum album*.

Record (29) writing in 1924, describes *A. balsamifera* as a tree 20–40 or more feet high, common in the West Indies and extending through northern S. America to Ecuador. It is exploited commercially chiefly in Venezuela, where it is usually known as " quigua." It is also known locally as " amyris legitimo " in order to distinguish it from *A. simplicifolia* Karst., and *A. sylvatica* Jacq., which are known as " candil di playa " and " candil di montana " respectively. Before 1914 it was exported chiefly to Germany for the extraction of West Indian sandalwood oil, and in smaller quantities to New York. Record also gives brief notes on the appearance and microscopical structure of the wood, which agree well with the features observed in the specimens examined during the present investigation.

Macroscopic Characters.

Wood yellow or yellowish-brown. Sapwood narrow, but in the one specimen large enough to show this character, not very sharply demarcated from the heartwood. Close grained, heavy. With pleasant characteristic smell. *Growth rings* distinct, boundaries marked by narrow, concentric bands of (terminal) parenchyma. *Rays* scarcely visible with a lens. *Pores* minute, fairly uniformly distributed ; chiefly in short radial chains.

Microscopic Characters.

Growth rings distinct, varying in width, boundaries marked by very distinct concentric zones of thick-walled parenchyma, but vessels more or less uniformly distributed. *Vessels.*—A few solitary, but mostly in radial groups of 2–11, very rarely in tangential groups or clusters. 15–35 vessels or vessel groups per sq. mm. Radial diameter of solitary vessels 20–80 (mostly 48–66)μ ; tangential diameter 20–56μ. Radial diameter of individual vessels from amongst those in groups 32–80μ, tangential diameter 32–64μ. Vessel elements 20–400 (mostly 200–325)μ long. Perforations simple, end walls horizontal or less frequently oblique. Deposits

common in vessels, but the frequency varying in different specimens. Intervascular pits bordered, crowded, small, rounded, with slit-shaped openings, chiefly in horizontal rows of 3 or 4. Occasional compound pits. Vessel-ray pits mostly bordered and half bordered, but rather difficult to see in some instances. *Parenchyma* chiefly present as terminal bands forming boundaries between the growth rings. Paratracheal parenchyma cells few. Vertical chains of 6–25 crystal-containing cells scattered throughout the wood, replacing the libriform fibres of which the groundwork of the wood is mainly composed, cells 20–60 (mostly 20–30)μ high. Terminal parenchyma cells thick-walled, mostly angular but sometimes rounded, usually in bands of 1–3 cells, but width varying in different parts of each band. *Fibres.*—Ground tissue of wood composed of libriform fibres, mostly with very thick walls ; rounded as seen in cross section, arranged in radial rows, about 12–16μ wide and about 450–650μ long. With very minute simple pits. *Rays* 10–14 per mm., very small, almostly exclusively uniseriate, but a few partly biseriate, 1–18 (mostly 6–12) cells high ; homogeneous ; cells with rather thick walls, 8–16 (mostly about 12)μ high, 4–16 (mostly 6–10)μ broad, the narrower cells usually towards the margins of the rays. Vessel-ray pits small, mostly bordered or half-bordered.

Material examined :—(1) Kew 48–1899. (2) Yale 743.

Extracts.

Aqueous and alcoholic extracts almost colourless. When shavings were boiled a faint smell, somewhat resembling Cinnamon, sometimes given off.

As was stated above this anatomical structure supports the suggestion that *A. balsamifera* has affinities with the *Rutaceae* rather than the *Burseraceae.* Thus Solereder (32) states that the vessels in the wood of the *Burseraceae* which are in contact with the ray parenchyma, "bear large simple pits with transitions to bordered pits. The large simple pits, groups of which frequently recall a scalariform perforation of a vessel, form an excellent character of the axis of the *Burseraceae.*" In *A. balsamifera,* however, these large simple pits were not observed. On the contrary the small-bordered or half-bordered pits in this position agree rather with Solereder's (l.c. p. 179) statement that " in all the *Rutaceae,* with the exception of *Skimmia* and *Orixa,* the walls of the vessels bear bordered pits where they are in contact with the wood- or ray-parenchyma cells."

Sandalwoods from E. Africa and Madagascar.

The botanical source of sandalwood oils of East African origin appears for many years to have been uncertain. In the " Pharmaceutical Journal " for 1898 (25) it states that " Stuhlmann and Volkens have discovered in East Africa a tree-like shrub, *Osyris tenuifolia* Engl., belonging to the natural order *Santalaceae.* The

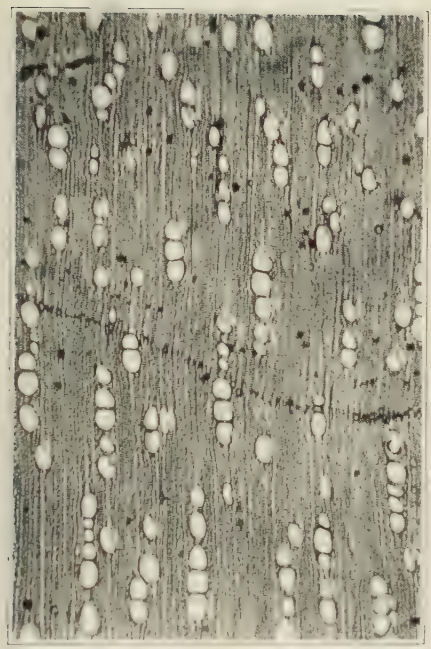

FIG. 13. *Amyris balsamifera.*
Transverse section. × 28.

FIG. 14. *Amyris balsamifera.*
Tangential section. × 57.

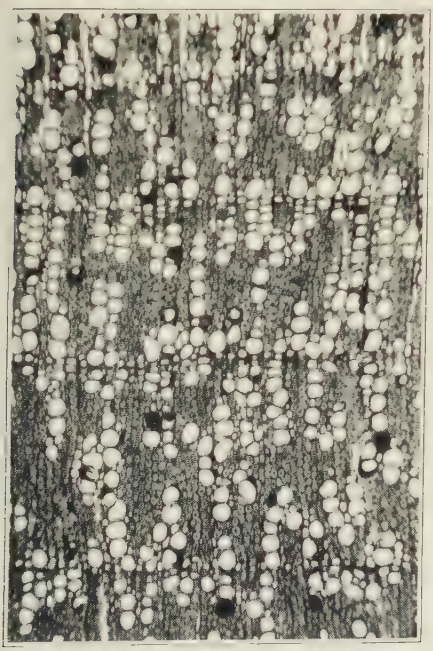

FIG. 15. *Brachylaena Hutchinsii.*
Transverse section. × 28.

FIG. 16. *Brachylaena Hutchinsii.*
Tangential section. × 57.

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agreeable smell is due to a brown resin with which the wood vessels are filled ; this originates in the cells of the medullary rays and the wood-parenchyma." No description of the wood is given beyond stating that it is very similar to genuine Indian sandalwood, and since no specimen of wood with this name has been available its identity must remain uncertain. Even as recently as 1932 there is evidence (21) that the identity of E. African sandalwood is uncertain as is shown by the following extract : " A circular issued from a government quarter in U.S.A. states that a concern in India has reported through the assistant trade commissioner at Calcutta to the Department of Commerce that one of its clients has obtained exclusive privilege for the exploitation of sandalwood in a large area in British East Africa. Amongst the varieties the exploiter is interested in supplying is a redwood, in lumps of 6–7 lbs. each, said to be rich in oil. The Indian concern says it has developed trade with several foreign countries. The botanical identity of the sandalwood is not disclosed . . . "

The information collected during the present investigation shows that sandalwood oil of East African origin is derived largely from members of the *Canellaceae*, and from the genus *Brachylaena* (*Compositae*). Sandalwood may also be obtained in this part of the world from members of the *Santalaceae*, but the exact botanical source must remain uncertain until reliable specimens of the wood accompanied by herbarium material are available.

Scented woods from E. Africa and Madagascar belonging to the Canellaceae.

In my previous article on scented woods (17) an account was given of the structure and uses of *Cinnamosma fragrans* Bail., a scented wood from Madagascar belonging to the *Canellaceae*. Further wood specimens of the *Canellaceae* have now come to hand, and the ones on which the description of *Cinnamosma fragrans* was based have been re-examined. This has led to the conclusion that certain of the specimens then believed to be *Cinnamosma fragrans* really belong to the closely related genus *Warburgia*. The wood structure of *Warburgia* spp. and *Cinnamosma fragrans* is in essentials very similar, and the description of the wood structure given under *C. fragrans* is inaccurate only in that it is sufficiently comprehensive to include also the wood of *Warburgia* spp.

Before enumerating the differences between these woods some additional information concerning their uses will be given. The three species of *Warburgia*, *Warburgia Stuhlmanni* Engl., *W. Breyeri* Pot. and *W. Ugandensis* Sprague, all occur on the mainland of E. Africa, while *Cinnamosma fragrans* and the closely related *C. Madagascariensis* Danguy are confined to Madagascar. A record of the commercial use of the bark of *Warburgia Stuhlmanni* is given in the " Pharmaceutical Journal " for 1911 (27), where it is stated that the bark of the " karumbusi " tree (*Warburgia Stuhlmanni*

Engl.) is an article of commerce in Zanzibar, where it is used in the same way as sandalwood. It was believed that the oil from this bark may have been used to adulterate E. African sandalwood oil (thought to be distilled from *Osyris* sp.). It is interesting to note the statement that the bark of *Warburgia* has been an article of commerce at Zanzibar, which is also reputed to be the centre from which the *Cinnamosma fragrans* of Madagascar is exported to India (17). It is thus clear that there is opportunity at Zanzibar for the products of these closely related genera to become confused.

A hot aqueous infusion of the wood of *Warburgia* spp. was found to have the same pleasant distinctive smell and yellowish-green colour and fluorescence as *C. fragrans*. Previous work on the anatomy of the leaf and stem based on herbarium material of *W. ugandensis* was carried out by Boodle (2). The anatomical features mentioned by Boodle agree with those seen during the present investigation. Moreover, Boodle mentions that the anatomy of the material he examined agreed well with that of American *Canellaceae* as given by Solereder (32).

The following are characters whereby the wood of the two genera can be distinguished.

Vessels.—In *Warburgia* spp. vessels more frequently in tangential or oblique pairs (transverse section) than in *C. fragrans*. *Fibres*.—Fibres of *Warburgia* spp. differ from those of *C. fragrans*. 1. In being less frequently in radial rows. 2. In being less rectangular in transverse section. 3. In having a wider lumen. *Parenchyma*.—In *C. fragrans* most vessels partly or wholly surrounded by paratracheal parenchyma. In *Warburgia* spp. paratracheal parenchyma cells relatively scarce, many vessels wholly or almost entirely surrounded by fibres. *Rays*.—In *C. fragrans* rays almost exclusively uniseriate, with a few partly biseriate. In *Warburgia* spp. most rays partly or wholly biseriate, rarely partly triseriate.

Material examined:—*Cinnamosma fragrans* (1) Yale 7367. (2) Vohilahitra from Madagascar. Kew 122–1891. *Warburgia Stuhlmanni*. Imperial Forestry Institute 864. *Warburgia ugandensis*. Specimen from unknown source, until recently used for class purposes at Cambridge University School of Forestry, kindly supplied by Mr. B. A. Jay. *Warburgia spp* (1) Calambac from the market at Kalantan. 1931. (2) Santal Vert. Zanzibar. A very old specimen with no date received from the University of Louvain.

(If the above list of material is compared with the one given under *C. fragrans* in my previous paper on scented woods, it will be seen which specimens have now been transferred from *C. fragrans* to *Warburgia* sp.).

Extracts.

Aqueous and alcoholic extracts yellowish-green and slightly fluorescent, rather yellower than those of *Cinnamosma fragrans*. If shavings are boiled a pleasant smell is given off.

Sandalwoods from E. Africa and Madagascar derived from the genus Brachylaena (Compositae).

In 1932 a sample of an unusual sandalwood, which was alleged to have come from India, was received at Kew. After some difficulty it was identified as *Brachylaena* sp. very similar to *B. Hutchinsii*. In a note by H. Perrier de la Bathie (22) it is stated that three kinds of sandalwood are exported from Madagascar to India where they are used for religious ceremonies. Two of these sandalwoods are referred to two species of *Santalina*, whilst the third is a species of *Brachylaena*. It is chiefly the stumps and old dead wood that are used in this way. According to Dr. Hutchinson the systematic position of the genus is near *Baccharis* and *Tarchonanthus*. These genera are represented by trees which are mostly dioecious and are very advanced members of the *Compositae*. Moreover he says that the wood of *Brachylaena* is a well-known sandalwood in E. Africa.

A description of the wood structure of *Brachylaena Hutchinsii* is here included, together with brief notes on other species.

Brachylaena Hutchinsii *Hutchinson*. (Figs. 15 and 16).

Macroscopic Characters.

Wood hard and comparatively heavy. Material insufficient to determine whether heart and sapwood differ markedly from one another. All specimens examined dark buff coloured, but the darkness varying. On transverse surfaces roughly concentric stripes of darker and lighter coloured wood present, ranging from dark brown through light brown to yellowish-brown. *Growth rings* distinct on transverse surfaces, boundaries marked by narrow bands comparatively free from vessels. *Pores* small, individual openings visible only with difficulty under a lens, very numerous, chiefly disposed in radial groups, more or less evenly distributed throughout the wood. " Islands " of very thick-walled fibres, darker in colour than the surrounding tissues, also present. *Parenchyma* scarce, chiefly associated with the vessels. *Rays* fine, just visible with a lens on transverse surfaces. *Ripple marks* moderately distinct.

Microscopic Characters.

Growth rings distinct, boundaries marked by narrow concentric bands of thick-walled elements strongly rectangular in cross section, and by vessels of smaller diameter than those elsewhere. *Vessels* storied, chiefly arranged in radial rows, in some instances the rows being adjacent to one another, or overlapping. Sometimes also in clusters. Individual groups coalesced or in frequent contact with each other, thereby making it almost impossible to count the number of vessel groups per sq. mm. Only the number of individual vessels per sq. mm. was therefore counted. These numbered 143–286 per sq. mm., the number varying in different specimens but more or less constant for any individual specimen. More or less

evenly distributed, but somewhat less frequent at the boundaries between the growth rings, and also where " islands " of libriform fibres (see below) were most abundant. Radial diameter of individual vessels 16–60 (mostly 28–40)μ, tangential diameter 20–60 (mostly 28–40)μ. Vessel elements remarkably uniform in length, 150–350 (mostly 250–300)μ, end walls mostly horizontal or slightly oblique, perforations simple. Intervascular pits minute, bordered, circular, with circular or slightly flattened apertures. Tracheids present amongst the vessels, distinguishable from the vessel elements only by the possession of non-perforated end walls. Vessel-ray pits bordered or half-bordered. Deposits present in a few vessels. *Fibres* in " islands " of varying and irregular shapes as seen in transverse section, occupying very varying proportions of the bulk of the wood at different points. Tendency for the " islands " to have their greatest width in a radial direction, but many exceptions to this. Fibre walls very thick, lumen almost obliterated, thickening laid down so as to give the appearance of concentric zoning in cross sections of the fibres ; rounded or angular and of varying diameter. Pits bordered, minute, rather infrequent, rounded. Fibres 250–700 (mostly 300–500)μ long, sometimes filled with deposits, not storied. *Parenchyma* chiefly paratracheal, in the form of isolated cells, or groups of a few cells together around some of the vessels, but not seen entirely surrounding any vessel. Terminal parenchyma present at boundaries of growth rings. Cells somewhat variable in size and shape, a small proportion filled with deposits. *Rays* 9–11 per mm., storied ; mostly uniseriate, sometimes partly biseriate, rarely triseriate for a very short distance. (One single, abnormally large ray observed consisting of 3 rows of cells similar in size to the majority of the ray cells, but having in addition a single row of much broader cells). 1–14 (mostly 7–11) cells high. Individual cells thick-walled, varying considerably in size and shape. Marginal cells usually somewhat pointed (tangential section). Tangential walls (as seen in radial sections) almost all vertical.

Material examined :—(1) Kew 67–1929. (2) Forest Products Research Laboratory 2694. (3) Imperial Forestry Institute 2057.

Brachylaena sp.

General colouring and texture of the wood similar to *B. Hutchinsii*. Microscopical structure differing in less frequent vessels of much wider diameter, solitary or in radial series, as well as in groups. *Growth rings* more distinct owing to the greater contrast between the terminal parenchyma and the groundwork of libriform fibres. Paratracheal parenchyma cells larger and more conspicuous. Walls of libriform fibres less thick than those of *B. Hutchinsii*, and concentric zoning in the thickening of the fibre walls less obvious. *Rays* with only a slight tendency to be storied, mostly wholly biseriate and many triseriate.

Material examined :—Yale 14946.

Brachylaena merana (*Baker*) *Humb.*

The one specimen available was extremely hard and heavy, but with the same general appearance as *B. Hutchinsii*. In microscopic structure in many respects intermediate between *B. Hutchinsii* and the unnamed species Yale 14946. General arrangement and diameter of the vessels and distribution of parenchyma similar to those in Yale 14946. *Fibres* with extremely thick walls, thickening zoned as in *B. Hutchinsii*. *Rays* storied, uniseriate and biseriate. Pitting very similar to that in *B. Hutchinsii*.

Material examined:—Yale 10767.

Extracts.

Aqueous and alcoholic extracts of the various species of *Brachylaena* pale yellow with a tinge of green. When shavings of any of them are boiled in water a pleasant smell is given off.

Owing to the comparatively small number of vessels in the individual radial groups and on account of the relative infrequence of the vessels and vessel groups the "island"-like appearance of the fibres in transverse sections was not apparent in any of the species besides *B. Hutchinsii*.

The 3 species of *Brachylaena* here described appear to form a series, with *B. Hutchinsii* and *B.* sp. Yale 14946 at either end and *B. merana* intermediate between them. The one abnormal ray observed in *B. Hutchinsii* is of interest as it indicates that there is a tendency for this species with relatively narrow rays occasionally to develop the broader type of ray characteristic of the other species.

(No material of the Santalinas from Madagascar mentioned by Perrier de la Bathie (22) was available during the present investigation, so it has been impossible to draw up descriptions of them. However, from the brief anatomical notes given by him it is quite evident that the Santalinas could not easily be confused with the *Brachylaena* sp. which he mentions. As would be expected, the structure is more similar to that of the other *Santalaceae* described in the present paper. In his Santalinas the vessels are stated to be very infrequent, solitary; diameter 12–15μ. Vessels elements about 400μ long. Pits in vessel walls small, arranged in 2–3 longitudinal rows. Fibres thick-walled, pitted, about 500μ long, arranged in very regular radial rows. Rays narrow, mostly uniseriate, cells elongated vertically. End cells of the rays pointed. No crystals present in rays).

Convolulus scoparius. L. Canary Rosewood. Bois de Teneriffe.

Convolvulus scoparius L., a species now confined to the Canary Islands, is stated to be the source of a scented wood of somewhat varying reputation. Reference is made to the oil distilled from the wood in a note published in 1887 (24) in which it is referred to as

rosewood oil. According to this note the yield of oil is so small that distillation is hardly remunerative, and the oil is so weak in odour that it is of little value in perfumery. It is mentioned, however, that when mixed with 20 times its weight of copaiba (*Copaifera*) oil it is used as a bait for wild rabbits and rats, which are attracted by the perfume.

Chevalier (4) on the other hand, writing in 1933 gives a very different account of this wood, to which he refers under the synonym *Rhodorhiza scoparia* Webb. and Berth. He believes the wood to be identical with " bois de Rhodes," " Lignum Rhodium " or " Aspalath," small pieces of which in ancient times were boiled for fumigation purposes. Chevalier points out that it is remarkable that the wood of a plant now confined to the Canary Islands should at one time have been used extensively throughout the Mediterranean region, but he is unable to decide whether it was distributed by caravan from the small region to which it is now confined, or whether the species was then more widely distributed. He also makes the suggestion that the plant might advantageously be cultivated, especially in Morocco.

An account of the general appearance and properties of Canary rosewoods was published in the " Kew Bulletin " for 1893 (14). It is stated in this article that the original *lignum rhodium* came from Macedonia, and that the name was transferred to the wood of *Convolvulus scoparius*. If this is true, the " aspalath " of the Greeks must have been derived from a distinct plant. Hence it is probable that the root wood of *Convolvulus scoparius* was not so widely used in the Mediterranean region as is to be inferred from Chevalier's article, although there is evidence that it was at one time extensively exported from the Canary Islands.

Convolvulus scoparius *L.* (*Convolvulaceae*). Root wood only. (Fig. 8).

(The following account of the anatomy of *Convolvulus scoparius* and *C. floridus* was drawn up by Mr. B. A. Jay).

General properties and Macroscopic Characters.

An extremely hard wood with straight grain and very fine texture. Heart wood golden-brown, sap wood greyish. Strongly scented when freshly cut. *Growth rings* not well defined. *Vessels* invisible to the naked eye, just visible with a lens, very numerous, appearing lighter in colour than the rest of the wood, not individually distinct under a lens. *Parenchyma* not visible with a lens. *Rays* visible with lens, very fine, numerous, lighter in colour than the rest of the wood.

Microscopic Characters.

Growth rings.—None apparent in material available. *Vessels*.—Fairly evenly distributed, but tending to be in tangential lines ;

mostly solitary but also in tangential groups of 2–3 (mostly 3), a few in radial pairs, or sometimes in irregular clusters. Radial diameter of solitary vessels 30–100 (mostly about 60)μ, tangential 30–80 (mostly about 50)μ.. 10–27 (mostly 16–20) solitary vessels or vessel groups per sq. mm. Vessel elements 170–250μ long, end walls somewhat oblique. Perforations simple. Intervascular pits bordered, in horizontal rows, alternate, borders circular, often appearing to have large, deeply scolloped tori, especially on radial walls; apertures circular to slit-like, not extending beyond border, horizontal. Vessel-parenchyma pits bordered, borders circular to oval with long axes horizontal, elongated apertures often somewhat oblique. Vessel-ray pits bordered, circular to oval with long axes horizontal, apertures slightly elongated, very large, irregularly arranged. *Fibres.*—Groundwork of wood composed of extremely thick-walled fibres, the lumen being much narrower than the walls. Tapering gently. Length 570–1200 (mostly 850)μ, irregularly arranged but here and there with a tendency to be in radial rows. Non-septate. Pits with circular borders and slit-like apertures, often crossed, numerous, evenly distributed, mostly on radial walls. Frequent clear yellow deposits. *Parenchyma.*—Paratracheal parenchyma infrequent, where present consisting of solitary cells or a few together. Metatracheal parenchyma very scarce, where present consisting usually of solitary cells. Diameter of cells 8–36 × 12–36 (mostly 16 × 20)μ, shape irregular in transverse section, ends horizontal. Pits between parenchyma cells simple. *Traumatic parenchyma.*—Irregular shaped groups of thin-walled cells present, mostly about 100 × 190μ as observed in transverse sections. Cells usually with resinous contents. Their mode of development and finer structural details could not be followed in the material available, so that their true nature is uncertain. It seemed possible that they might consist of included phloem, but Dr. L. Chalk of the Imperial Forestry Institute, Oxford (who is making a special study of included phloem) kindly examined one of my slides and expressed the view that the patches consist of traumatic tissue. *Rays* 6–14 (mostly 10) per mm., frequently contiguous to vessels; 1–4 (mostly about 2) seriate, 1–18 (mostly about 9) cells high. Height 30–600 (mostly about 150)μ, width (maximum) 8–50 (mostly about 20)μ. Not storied. Cells 20–50 × 8–30 (mostly 24 × 12)μ, oval with longer axes vertical, in radial section much longer than high, marginal cells no larger; tangential walls (radial section) vertical or slightly oblique; transverse walls (radial section) often considerably and irregularly thickened. Pits in radial walls between ray cells few, with borders and apertures circular to oval. Pits in transverse and tangential walls simple. Abundant yellow deposits.

Material examined :—(1) Kew 142–1909.

Extracts.

Aqueous extract almost colourless, but becoming pale lemon coloured on the addition of dilute ammonia. Alcoholic extract

very pale lemon coloured, but colour intensified by adding dil. ammonia. When boiled in water gives off a pleasant, characteristic scent.

Convolvulus floridus *L.* (*Convolvulaceae*).

The wood of this species, which is also a native of the Canary Islands, has essentially the same structure as that of *C. scoparius*, but it differs in the following characters :—

The wood is pale yellow with no differentiation into heart and sapwood. Very little scent when cut or boiled.

Growth rings clearly defined as light coloured rings, being formed by 2–5 layers of thin-walled fibres (mostly radially flattened) contiguous to layers of thick-walled fibres. *Vessels.*—No tendency to be in tangential lines, very rarely grouped. Radial diameter of solitary vessels 50–136 (mostly about 100)μ, tangential 34–120 (mostly 85)μ. 4–14 (mostly 6–9) solitary vessels per sq. mm. Vessel elements 160–360μ long. *Fibres.*—Deposits rare. *Rays* 30–820 (mostly about 250)μ high, and 8–80 (mostly about 25μ wide, cells slightly larger than in *C. scoparius*. In radial section cells tend to be square. Deposits rare.

Material examined :—Kew 142–1909.

Extracts.

Aqueous and alcoholic extracts of same colour as those given by *C. scoparius*, but no scent given off when shavings are boiled.

Urandra sp. Daru-daru or Dedaru (*Olacineae*. Tribe Icacineae).

Although the wood sold in the Singapore market as daru-daru or dedaru is not truly a sandalwood, it is, nevertheless, very strongly scented when boiled in water, and it is therefore, included in the present paper. The only specimen available was one from the market at Singapore, kindly supplied by Mr. R. E. Holttum. Its exact botanical identity must be uncertain since it was not accompanied by herbarium material.

The following anatomical description was drawn up by Mr. B. A. Jay.

General Properties and Macroscopic Characters.

An extremely hard wood with straight and very fine grain, somewhat oily in texture. Specimen too small to show if any differentiation into heart and sapwood. Light brown. Strongly scented when boiled in water. *Growth rings.*—None clearly defined. *Vessels* visible to the naked eye, numerous, evenly distributed, mostly solitary. *Parenchyma.*—None visible with lens. *Rays* very fine, numerous, just visible to naked eye, but quite distinct with lens ; lighter in colour than the rest of the wood. *Ripple marks* absent.

Growth rings.—None seen. *Vessels.*—Evenly distributed, mostly solitary but also in radial (occasionally tangential) pairs, no clusters observed. Frequently contiguous to the rays. Radial diameter of solitary vessels 60–240 (mostly about 160)μ, tangential diameter 102–190 (mostly about 140)μ. Number of solitary vessels and pairs per sq. mm. 3–8 (mostly 4–5). Vessel elements very short, 85–425μ. (mostly about 250)μ long, end walls mostly horizontal, a few very oblique. Perforations simple. Some vessels filled with deposits. Intervascular pits bordered, irregularly arranged, borders oval with longer axes horizontal, apertures elongated (mostly beyond border) and horizontal. Vessel-parenchyma pits bordered, borders circular to oval with long axes horizontal, apertures circular or elongated horizontally; large, fairly numerous. Vessel-ray pits simple to half-bordered, large, circular to very elongate, not very numerous. *Fibres.*—Groundwork of wood composed of extremely thick-walled fibres, very angular as seen in transverse sections. Lumen often almost obliterated. Length 750-2500 (mostly 1700–1750)μ. Arranged in irregular radial rows, unseptate. Pits (very clearly seen in transverse sections) mostly in tangential rows, tending to be most frequent in the middle of the fibres, bordered, borders circular and large, apertures elongated vertically (not extending beyond the borders). Lumen in a large proportion filled with deposits. *Parenchyma.*—Paratracheal parenchyma fairly frequent, but not observed entirely surrounding the vessels. Metatracheal parenchyma fairly frequent, usually in groups of 2–4 cells (transverse section). Diameter 19–47×15–47 (mostly 38×23)μ, shape irregular in transverse section, rectangular but elongated vertically in radial and tangential sections, end walls horizontal. Pits between cells simple, irregular in shape, not very numerous, sometimes in clusters, unevenly distributed. *Rays* 4–7 (mostly 5) per mm., 1–4 (mostly 3) seriate, 5–65 (mostly 25) cells high; heterogeneous. Height 187–1620 (mostly 680)μ, width 18–60 (mostly 40)μ, not storied. Cells 11–24×14–43 (mostly 17–27)μ, oval with longer axes vertical; marginal cells considerably elongated. Tangential walls (radial section) mostly vertical or somewhat oblique. Pits in radial walls between ray cells simple, small, not very numerous, apertures circular to oval, irregularly arranged. Pits in transverse and tangential walls simple. No deposits observed.

Material examined:—Singapore. R. E. Holttum. Specimen received in 1933.

Extracts.

Aqueous and alcoholic extracts almost colourless. When shavings are boiled a pleasant characteristic scent is given off.

I am greatly indebted to all those individuals and institutions who have assisted in providing wood specimens and information. Amongst these my thanks are especially due to the Directors of the

Imperial Forestry Institute Oxford, and the Forest Products Research Laboratory, Princes Risborough, to Prof. S. J. Record of Yale University School of Forestry, the Forestry Commission of N.S. Wales, the Department of Woods and Forests, Queensland, and to Mr. A. R. Penfold of the Technological Museum, Sydney. In addition, considerable assistance was afforded by Mr. B. A. Jay, a visitor working at the Jodrell Laboratory, who examined and drew up descriptions of a few of the woods and took the photographs of the wood sections.

List of References.

1. Bentham G. and Hooker J. D. "Genera Plantarum." (1862 onwards).
2. Boodle L. A. in *Journ. Linn. Soc. Bot.* **37,** 498, (1906).
3. Bradfield A. E., Penfold A. R. and Simonsen J. L. in *Trans. and Proc. Roy. Soc. N.S. Wales.* **66,** 420, (1933). Quoted in *Perfumery and Essential Oil Record* **24,** 125, (1933).
4. Chevalier A. in *Rev. bot. appliq. et d'agric, trop.* no. 141, 347, (1933).
5. Engler A. Nat. Pflanzenfam. ed. 2, **19A,** 313, (1931).
6. Engler A. and Gilg E. "Syllabus der Pflanzenfamilien." Berlin, 1924.
7. Fischer C. E. in *Indian Forester,* **58,** 48, (1932).
8. Gamble J. S. "A Manual of Indian Timbers." London, 1902.
9. Greenish "Microscopical Examination of Food and Drugs." p. 69, London, 1903.
10. Holmes E. M. in *Pharm. Journ.* ser 3, **16,** 819 (1886).
11. Holmes E. M. in *Pharm. Journ.* ser **4, 8,** 53 (1899).
12. Hutchinson J. "The Families of Flowering Plants." London, 1926.
13. Janssonius H. H. "Mikrographie des Holzes der auf Java vorkommenden Baumarten" **4,** 164, Leiden, 1914.
14. *Kew Bulletin,* 1893, 133.
15. Kirby W. in *Pharm. Journ.* ser 3, **16,** 1065, (1886).
16. Kissel S. L. in *Perfumery Record* **18,** 169, (1927).
17. Metcalfe C. R. in Kew Bull. 1933, 3–15.
18. Official Guide to Kew Museum no. 1. 1930, 56.
19. Pearson R. S. and Brown H. P. "Commercial timbers of India." Calcutta, 1932.
20. Penfold A. R. in *Perfumery and Essential Oil Record,* **23,** 349, (1932). (Article reproduced from *Journal of Education.* No date).
21. *Perfumery and Essential Oil Record.* **23,** 328, (1932).
22. Perrier de la Bathie H. in *Rev. bot. appliquée et d'agric. trop.* **10,** 590–2, (1930).
23. Petersen A. in *Pharm. Journ.* ser. 3, 757, (1886).
24. *Pharm. Journ.* ser. 3, **18,** 343, (1887).

25. *Pharm. Journ.* ser. 4, **6**, 46, (1898).
26. *Pharm. Journ.* ser. 4, **8**, 215, (1899).
27. *Pharm. Journ.* ser. 4, **32**, 461, (1911).
28. *Pharm. Journ.* ser. 4, **38**, 278, (1914).
29. Record S. J. "Timbers of Tropical America." New Haven, 1924.
30. Sawyer J. C. "Odorographia." London, 1892.
31. Sen Gupta H. in *Indian Forester*, **57**, 630, (1931).
32. Solereder H. "Systematic Anatomy of the Dicotyledons." Oxford 1908.
33. Sprague T. A. and Summerhayes V. S. in *Kew Bull.* 1927, 193.
34. Swallow E. in *Pharm. Journ.* ser 4, **67**, 261, (1928).
35. *Tropical Woods*, no. 36, 1–12, (1933).
36. Watt, Sir G. "Dictionary of Economic Products of India." Calcutta, 1899.
37. Watt, Sir G. "The Commercial Products of India." London, 1908.

XVI—AFRICAN ORCHIDS: VII.* V. S. Summerhayes.

Habenaria chirensis *Rchb. f.* Otia Bot. Hamburg. 99 (1881); Rolfe in Dyer, Fl. Trop. Afr. **7**, 238 (1898); Kraenzl. Orchid. Gen. et Sp. **1**, 268 (1898). *Habenaria limnophila* Summerhayes in Kew Bull. 1931, 381.

When I described *H. limnophila* I was unable to match it with any of the descriptions of previously described species. As, however, it has proved to be a very common plant in northern Tropical Africa, it seemed likely that it had been described before. On examining the type specimen of *H. chirensis* Rchb. f. in the Reichenbach Herbarium there can be no doubt that the two are identical. Unfortunately the original description is incorrect in two particulars Reichenbach states "tepalis bipartitis, partitione superiori lineari, inferiori linearilancea, subaequali, labelli partitionibus filiformi subulatis subaequalibus." In the specimen, however, the anterior (inferior) lobe of the petal is considerably larger than the posterior (6·7 to 4·5 mm.), while the middle lobe of the labellum is much longer than the lateral lobes (10 to 6 mm.). These errors are, I believe, due to the fact that Reichenbach examined an incompletely opened flower in which the parts had not properly elongated.

Rolfe added to the confusion by interpreting Reichenbach's expression "partitione inferiori subaequali" as meaning "anterior lobe nearly as long as the posterior." He also states in his key (Fl. Trop. Afr. **7**, 210) that the stigmatic processes are less than 2 lines long, but there is no evidence for this in the original description; in fact they are 2½–3 lines long in the type specimen.

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* Continued from K.B. 1934, 214.

The type of *A. chirensis* shows very well the two characteristic features of the species, namely, the spur almost equally thickened throughout its length except for the very apex which is slightly widened and almost truncate, and the exceptionally large bilobed staminodes. The species is correctly placed in sect. *Bilabrellae*, not in sect. *Cultratae* as stated by Reichenbach nor in sect. *Dolichophyllae* as stated by Kraenzlin.

Habenaria (§ **Plantagineae**) **Jacobi** *Summerhayes*, sp. nov.; *H. xanthochilam* Ridl. revocans, sed statura minore, foliis angustioribus, floribus paucis, labelli lobis pectinato-denticulatis differt.

Herba terrestris, 12–13 cm. alta. *Tubera* longiuscule stipitata, ellipsoidea, vix 1 cm. longa. *Caulis* erectus, teres, gracilis, inferne 4–5-foliatus, apice 1–2-florus. *Folia* linearia vel lanceolato-linearia, basi vaginantia, apice acuta, leviter recurvata, 1–4·5 cm. longa, 2–4 mm. lata. *Flores* erecti, verosimiliter partim albi partim virides; bracteae lanceolatae, acuminatae, 7–12 mm. longae; pedicelli cum ovario 12–14 mm. longi. *Sepalum* intermedium erectum, ovatum, acutum, valde concavum, 7 mm. longum, 4 mm. latum; sepala lateralia reflexa, late semi-ovata, obliqua, leviter acuminata, 7·5 mm. longa, 3·2 mm. lata. *Petala* linearia, leviter falcata, antice basi abrupte dilatata, 5·5 mm. longa, 0·7 mm. lata, cum sepalo intermedio agglutinata. *Labellum* ex ungue lineari 2·5 mm. longo tripartitum, ambitu transverse ellipticum, in toto 1 cm. longum et latum; partitio intermedia unguiculata, obcordatim biloba apiculo interjecto, 7·5 mm. longa, 7 mm. lata, lobis lateralibus breviter pectinato-denticulatis; partitiones laterales oblique anguste obovatae, margine antico fere recto, 7 mm. longae, 2·8 mm. latae, margine postico superne pectinato-denticulatae; calcar dependens, superne leviter inflatum et recurvatum, acutum, circiter 3 cm. longum. *Anthera* 2·5–3 mm. alta, apice rotundata, canalibus leviter incurvato-porrectis 3 mm. longis; staminodia parva, integra. *Rostelli* lobus intermedius breviter triangularis, acutus, 0·7 mm. longus; brachia stigmatifera crasse clavata, obtusissima, leviter recurvata, circiter 2·5 mm. longa.

French Guinea. Environs of Kindia, 1929–1932, *Jacques* 140 (Type in Herb. Mus. Paris.).

Here is yet another West African representative of sect. *Plantagineae*, but one quite unlike the other two species from this region (*H. Engleriana* Kraenzl. and *H. prionocraspedon* Summerhayes). In habit *H. Jacobi* resembles several Indian species, e.g. *H. longicornu* Lindl. and *H. longicalcarata* A. Rich., but is much smaller. In lip structure it approaches most closely *H. xanthochila* Ridl., a native of the Malay Peninsula. In that species, however, the lip segments are all quite entire instead of being shortly pectinate as in *H. Jacobi*. The characteristic feature of both of these species is the bilobed middle-lobe of the lip, this lobe in most members of the section being quite narrow, not lobed and with an entire margin. This is well shown in the two West African species mentioned above

and in *H. decorata* Hochst. from East Africa. *H. Jacobi* bears a strong resemblance to *Cynorchis parva* Summerhayes, which also occurs in French Guinea ; in the *Habenaria*, however, the much longer stigmatic arms are quite free from the lateral lobes of the rostellum, not united to them as in *C. parva*. Nevertheless it is possible that the latter is better placed in *Habenaria* than in *Cynorchis*. An exact line of demarkation between the two genera is yet to be discovered.

Polystachya (§ **Caulescentes**) **rhodoptera** Rchb. f. in Hamburg. Gartenzeit. **14**, 214 (1858). *P. ensifolia* Lindl. in Journ. Linn. Soc. Lond. Bot. **6**, 129 (1862). *P. pyramidalis* Lindl. l.c. 130. *P. carnea* A. Brongn. in Fl. des Serres, **15**, 45, t. 1521 (1862 3). *P. sulphurea* A. Brongn. l.c. *P. Wahisiana* De Wild. Not. Pl. Utiles Congo, 318, t. xxi (1904). *P. subcorymbosa* Kraenzl. in Kew Bull. 1926, 288.

A careful comparison of type specimens, descriptions and figures of the above " species " makes it evident that they must be considered as belonging to a single species. There is considerable variation in the size of the plant, the width of the leaves, the amount of branching of the inflorescence (this may be simple in a few cases) and the shape of the lip. I have, however, seen intermediates linking up all the extreme forms, and the general facies both vegetative and floral throughout the species is quite constant.

The name " rhodopterya " first published by Reichenbach was later corrected by him as being a typographical error, the spelling as given above being correct.

Polystachya laxiflora *Lindl.* in Journ. Linn. Soc. Lond. **6**, 129 (1862). *P. galericulata* Rchb. f. Otia Bot. Hamburg. 111 (1881). *P. dixantha* Rchb. f. in Gard. Chron. ser. 2, **17**, 294 (1882).

It is obvious from an examination of the type specimen that *P. dixantha* Rchb. f. merely represents an individual of *P. laxiflora* Lindl. in which the branches of the inflorescence have not developed, probably due to unsatisfactory conditions of cultivation (the species was described from a cultivated specimen). These branches are easily visible as very short bud-like outgrowths in the axils of the bracts. In addition the leaves are somewhat narrower than is usual in *P. laxiflora*, but there are specimens in the Kew Herbarium which possess equally narrow leaves together with the normal branched inflorescences. In structure the flowers in Reichenbach's species are identical with those of *P. laxiflora*.

It should be noted that in spite of the remarks by Kraenzlin on pp. 20 and 128 of his monograph of the genus, *P. galericulata* Rchb. f. is correctly placed by Rolfe as a synonym of *P. laxiflora*. The type specimen is at Kew and consists of stems bearing mostly only a single leaf, although one stem has two leaves. The stems (shape), leaves, inflorescences and flowers exactly match those of *P. laxiflora* and are quite unlike those of *P. cultriformis* Spreng.

Polystachya (§ **Elasticae**) **monolenis** *Summerhayes* sp. nov.; affinis *P. reflexae* Lindl., a qua floribus minoribus, labello basi ecalloso medio pulvino singulo pubescente instructo differt.—*P. expansa* Ridl. in Bol. Soc. Brot. **5,** 198 (1887), partim; Rolfe in Dyer, Fl. Trop. Afr. **7,** 122 (1897), partim.

Herba nana, epiphytica; pseudobulbi breviter cylindrici, circiter 1 cm. longi, vaginis obtecti, basi radicibus numerosis flexuosis. *Folia* non visa. *Inflorescentia* 5–8 cm. alta, basi vagina membranacea 2·5 cm. longa inclusa, superne dense multiflora, racemo 1·5 cm. diametro; rhachis breviter pubescens; bracteae ovatae, acuminatae vel apiculatae, 1–2 mm. longae. *Flores* patentes. *Sepalum* intermedium elliptico-ovatum, dorso apiculatum, concavum, 2·8 mm. longum, 1·8 mm. latum; sepala lateralia inaequaliter rotundato-triangularia, dorso infra apicem apiculata, margine juxta sepalum dorsale 3–3·2 mm. longo, margine altero 4·6–4·8 mm. longo, basi cum pede columnae mentum obtusum 4 mm. longum formantia. *Petala* spathulato-oblonga, oblique obtusa, 2·4 mm. longa, 1·1–1·3 mm. lata. *Labellum* basi trilobatum; lobi laterales lineares, breves ab intermedio angulo 45° divergentes; lobus intermedius basi geniculatim reflexus, ex ungue brevi ellipticus, apice rotundatus, 5 mm. longus, 2·5 mm. latus, medio pulvino singulo pubescente instructus. *Columna* crassa, 0·8 mm. longa; anthera quadrato-hemisphaerica, antice longe rostrata; pollinia 4, ellipsoidea, stipite lineari 1·2 mm. longa, viscidio obtuse lunato.

Sierra Leone: 1828, *Wilford* (Type in Herb. Mus. Brit.).

This species was confused with two specimens from the island of St. Thomas. It is clear from the description of *P. expansa* Ridl. that the Sierra Leone specimen is not the type since the species is said to have an entire lip with a tooth-like callus at its base.

P. monolenis is yet another member of the interesting section *Elasticae* which so far as is known is almost restricted to West Africa. Unfortunately Kraenzlin omitted *P. saccata* (Finet) Rolfe and *P. Pobeguinii* (Finet) Rolfe, from his monograph of the genus. On the other hand *P. rhodoptera* Rchb. f., which was included in sect. *Elasticae* by Kraenzlin, belongs to sect. *Caulescentes*, and I feel doubtful about *P. usambarensis* Schltr., which, judging from the description, seems more suitably placed elsewhere. The section, so far as my investigations go, consists of the following species:—*P. elastica* Lindl., *P. reflexa* Lindl., *P. Victoriae* Kraenzl., *P. expansa* Ridl., *P. Pobeguinii* (Finet) Rolfe, *P. saccata* (Finet) Rolfe, *P. pseudo-Disa* Kraenzl., *P. Dalzielii* Summerhayes and *P. monolenis* Summerhayes. I have not seen *P. expansa* and it may possibly be conspecific with one of the others mentioned, although from the description it seems distinct.

Polystachya alpina *Lindl.* in Journ. Linn. Soc. Lond. Bot. **6,** 131 (1862). *P. Preussii* Kraenzl. in Engl. Jahrb. **17,** 51 (1893). *P. Winkleri* Schltr. l.c. **38,** 154 (1906). *P. Talbotii* Rolfe in Kew Bull. 1910, 282.

These are all forms of the same species as an examination of the type specimens shows. The callus of the lip is variously lobed in the different specimens but has the same general basic structure in all, while in other features the flowers are almost identical. The type specimen (*Mann* 647) consists of very dwarfed individuals with a much reduced 1-flowered inflorescence.

Polystachya golungensis Rchb. f. in Flora, **48,** 185 (1864). *P. mayombensis* De Wildem., Not. Pl. Util. Congo, 134, (1903), 317 (1904). *P. coriacea* Rolfe in Kew Bull. 1913, 340. *P. Johnsonii* Kraenzl. in Kew Bull. 1926, 291.

On examination of the four species cited above I am unable to discover any differences which can be considered as sufficient for specific separation. The leaves certainly vary in width in different individuals but this feature cannot be correlated with any other differences. The remarkable compact cushion of multicellular hairs at the base of the lip is borne on a thickened callus. As a result of variations both in the thickness of the callus and in the length of the hairs this cushion assumes different shapes in different specimens. In the type specimen of *P. golungensis* the apparent total callus produced is quite prominent, but it is linked by intermediates with quite a low cushion in *Johnson* 588.

The species is distributed from the Ivory Coast eastwards to Mt. Elgon in the north and to Angola in the south-west. So far it has not been recorded from south-east Tropical Africa.

Both *P. golungensis* and *P. coriacea* were placed by Kraenzlin in sect. *Calluniflorae* in his monograph of the genus. *P. Johnsonii*, which was described subsequently, he referred to sect. *Eupolystachyae*, which is undoubtedly the correct position. *P. golungensis* resembles in general features many species of this section but has smaller flowers than most of them.

Polystachya Sandersoni *Harv.* Thes. Cap. **2,** 49, t. 177 (1863). *P. pachyglossa* Rchb. f. in Linnaea, **41,** 73 (1877) and in Xenia Orchid. **3,** 9, t. 207, fig. 1 (1878).

Reichenbach described *P. pachyglossa* from a plant cultivated in the Royal Botanic Gardens, Kew, in 1870, which was stated by the "gardener" (unnamed) to have come from West Africa and probably from Sierra Leone. This origin was accepted by Rolfe in the Flora of Tropical Africa and later by Kraenzlin in his monograph of the genus. No further specimens agreeing with the original have been so far discovered in West Africa, but a careful comparison with the South African species of the genus reveals so close a resemblance between *P. pachyglossa* and *P. Sandersoni* Harv. that it is impossible to discover any really satisfactory difference.

On consulting the correspondence in the library at Kew it is clear that Mr. McKen, the superintendent of the Durban Botanic Gardens, Natal, sent many living plants of Orchidaceae to Kew between the years 1865 and 1875. Among these were gatherings

of *P. Sandersoni* of which there is corresponding dried material and sketches in the Kew Herbarium. In particular Sanderson, who was in close touch with McKen, sent a living plant of his number 895 in 1868 and it is remarkable that there is a sketch of this number in Reichenbach's herbarium on the same sheet as the type specimen of *P. pachyglossa*. In my opinion the latter species was described from one of the plants sent over from Natal by McKen or Sanderson and the supposed Sierra Leone origin is due to some confusion in labels or mixing of consignments from the two localities.

Bulbophyllum Milesii *Summerhayes*, sp. nov.; affinis *B. coriscensi* Rchb. f. et *B. elongato* De Wildem., ab utroque floribus minoribus, ab illo labello eciliato sed tantum papilloso, stelidiis duplo majoribus, ab hoc petalis lineari-oblongis acutis, scapo breviore, pseudobulbis duplo minoribus distinguitur.

Herba epiphytica, nana, repens. *Pseudobulbi* 5–10 mm. distantes, ovoidei, compressi, 7–10 mm. longi, circiter 4 mm. lati, apice unifoliati. *Folia* non visa. *Scapus* gracilis, erectus, 3·5 cm. longus ; pedunculus rhachidem aequans, vaginis 3–4 breviter acuminatis 3–6 mm. longis instructus ; rhachis teres, glabra ; bracteae lanceolatae, acuminatae, 3–5 mm. longae. *Flores* cremei ; pedicelli cum ovario 2 mm. longi. *Sepalum* intermedium anguste lanceolatum, acutissimum, 4·5–5 mm. longum, 0·7 mm. latum ; sepalum lateralia elongato-triangularia, leviter obliqua, acuta, 5–5·5 mm. longa, basi 1·2 mm. lata ; omnia sepala glabra. *Petala* lineari-oblonga, acuta, leviter curvata, 2 mm. longa, 0·4 mm. lata. *Labellum* ligulatum, obtusum, leviter curvatum, 1·8 mm. longum, 0·7 mm. latum, medio leviter sulcatum, duabus trientibus distalibus dense papillosum. *Columna* brevis, crassa, 0·6 mm. alta, stelidiis erectis lineari-subulatis 0·9 mm. longis coronata. *Anthera* breviter rostrata, linea media papillosa instructa.

Gold Coast. Western Province, common, Nov.—Dec. 1912, *Miles* 19.

A not very remarkable species belonging to the group of *B. flavidum* Lindl., but characterised by its small pseudobulbs.

Bulbophyllum Sect. **Megaclinium.**

There has always been a considerable difference of opinion as to the status which should be given to this group. In the Flora of Tropical Africa Rolfe treated it as a distinct genus, but Reichenbach and Schlechter almost invariably looked upon it as merely a section of *Bulbophyllum*. De Wildeman, in a recent survey of the African species of *Bulbophyllum*, decided also on the latter course, but Kraenzlin has recently again raised the possibility of maintaining the two genera as distinct.

The difficulty has always been one of deciding what are the diagnostic features of *Megaclinium*. Rolfe considered the swollen and/or flattened rhachis and markedly unequal sepals as the distinguishing characters of the genus. This division clearly breaks

down with such species as *B. calyptratum* Kraenzl. and *B. filiforme* Kraenzl. which Rolfe included in *Bulbophyllum* on account of the slender rhachis but which obviously possess the flowers of his *Megaclinium*.

Kraenzlin tried to avoid the difficulty by creating three sections of *Megaclinium* in which the (for him) 2 essential features of thickened rhachis and spathulate dorsal sepal were present, either together or singly (Vierteljahrschr. Nat. Ges. Zürich, **68**, 424 : 1923). This arrangement, however, still omits a number of species which are clearly more closely allied to *Megaclinium* than to the rest of the African *Bulbophyllums*.

De Wildeman (Pl. Bequaert. **1**, pp. 53–101 : 1931) makes no attempt to define his subgenus *Megaclinium*, nor does he consider very fully the characters which have been used for distinguishing it from *Bulbophyllum* proper, but it is more concerned with the validity or otherwise of characters for the delimitation of species. So far as can be seen from his lists of the species of the two subgenera *Megaclinium* and *Eubulbophyllum* his dividing line is the same as Kraenzlin's.

Recently I have had the opportunity of examining critically over 80 African " species " of *Bulbophyllum* and have come to the conclusion that *Megaclinium* can be maintained only as a section of *Bulbophyllum*. I have found it necessary to transfer to sect. *Megaclinium* several species previously included in " *Eubulbophyllum* " in order to obtain a relatively sharp line of demarkation between the two sections. These are as follow, *B. bibundiense* Schltr., *B. calyptratum* Kraenzl., *B. falcipetalum* Lindl., *B. filiforme* Kraenzl. and *B. Rhizophorae* Lindl. *B. Simoni* Summerhayes (*Megaclinium lasianthum* Kraenzl.) was also included wrongly in sect. *Eubulbophyllum* ; it is not conspecific with *B. Rhizophorae* as suggested by Schlechter and De Wildeman.

An examination of all the species of sect. *Megaclinium* available reveals a great similarity in floral structure quite apart from the nature of the rhachis. The sepals are very characteristic, the dorsal being fleshy, upright or curved, in some species narrow and acute, in others broad, spathulate and obtuse, with numerous intermediates. It is almost invariably longer, often much longer, than the laterals, which are broad and markedly falcate, with the distal half more or less and often abruptly reflexed. The sepals may be shortly hairy outside especially on the lower parts, but are never ciliate. There is nothing very striking about the petals except that they are almost invariably falcate in shape, this being much more marked in some species than in others.

The lip is very characteristic, being one of the most constant features of the group. In a few species it is pectinately divided at the base but in most it is entire, and is never ciliate or hairy. In fact I have so far never observed the papillae which are so frequently found in other African Bulbophyllums. The lip is relatively thin and flattened, and usually markedly curved, the lower surface

being usually provided with a longitudinal keel which prevents it from being flattened out. In some species e.g. *B. Pobeguinii* (Finet) De Wildem. and *B. Bufo* (Lindl.) Rchb. f. this keel is very well developed.

The column also possesses characteristic features. The stelidia are rarely much developed, being usually relatively short and in a few cases almost obsolete. In most species there is a broad wing on either side of the column which frequently terminates just below the stelidia in a rounded or triangular free lobe, each lobe being apparently folded inwards across the stigmatic surface, at any rate during part of the floral development.

The combination of all the features mentioned above gives the flower a very characteristic and distinctive appearance quite different from that of the flowers of the other African species of *Bulbophyllum*.

With regard to vegetative characters it may be noted that the pseudobulbs are usually 2-leaved but there are perhaps a half-a-dozen species known which possess 1-leaved pseudobulbs, and 1 or 2 in which the pseudobulbs are 3-leaved.

During the detailed examination of over 30 so-called species of sect. *Megaclinium* it has become evident that many of the characters used as criteria for distinguishing species are quite useless. In particular the degree of widening of the rhachis is of little importance. Provided the rhachis is flattened at all there seems to be no definite width in any given species ; most species with this type of rhachis show considerable variation in this respect combined with great uniformity in floral structure. The colour of the rhachis is also of little value, many species possessing forms with green or variously coloured rhachis respectively.

I have therefore been compelled to consider many species as identical with one another ; the names accepted and synonyms will appear in my treatment of the genus *Bulbophyllum* in the Flora of West Tropical Africa.

Among the gatherings examined are two which appear to represent undescribed species. I append the descriptions of these two species ; both possess 1-leaved pseudobulbs.

Bulbophyllum (§ **Megaclinium**) **Linderi** *Summerhayes*, sp. nov.; affine *B. leucorrhachidi* (Rolfe) Schltr., a quo pseudobulbis monophyllis, columnae alis sub stelidiis haud dentatis differt.

Herba epiphytica ; rhizoma repens, teres, crassiusculum, circiter 3–4 mm. diametro. *Pseudobulbi* 2–3·5 cm. distantes, elongato-ovoidei, obscure 3-angulati, 3–4·5 cm. longi, inferne 1–1·5 cm. diametro, apice monophylli. *Folia* anguste elliptico-oblonga, breviter petiolata, obtusa, 10–20 cm. longa, 1·3–2·2 cm. lata. *Scapi* solitares vel terni, 14–24 cm. longi, erecti rhachide plus minusve falcata ; pedunculus 11–15 cm. longus, subgracilis, vaginis pluribus obtusis subdistantibus 4–5 mm. longis instructus ; rhachis carnosa, subcompressa, 3–5 cm. longa, 3·5–5 mm. lata ; bracteae late ovato-triangulares, obtusae vel rotundatae, basi 3–5 mm. latae, deinde

reflexae. *Flores* cremei, e linea media utriusque rhachidis lateris exorti. *Sepalum* intermedium anguste lanceolatum, acutum, incurvatum, 7·5 mm. longum, 1·5 mm. latum ; sepala lateralia valde oblique falcato-ovata, acuta, 4·5 mm. longa, basi 2·5 mm. lata, superne reflexa. *Petala* linearia, acutata, falcata, 6 mm. longa, 0·6 mm. lata, dense papillosa, uninervia. *Labellum* valde curvatum, ambitu elongato-ovatum, obtusum, superne integrum, basi ciliato-pectinatum, apice papillosum, circiter 2 mm. longum. *Columna* incurvata, 2·5 mm. longa, alis integris ; stelidia breviter subulata. *Ovarium* glabrum, 3 mm. longum.

Liberia. Bumbuma, edge of original forest, on fallen decaying log, Oct. 31st, 1926, *G. M. Allen in Linder* 1325. " Flowers cream-colour."

One of the group with a much swollen only slightly flattened rhachis and broad triangular bracts nearly the width of the rhachis. The species is clearly closely allied to *B. leucorrhachis* (Rolfe) Schltr., which has 2-leaved pseudobulbs –in spite of the description in the Flora of Tropical Africa—as an examination of the Type specimen easily shows.

Bulbophyllum (§ **Megaclinium**) **magnibracteatum** *Summerhayes*, sp. nov.; affine *B. bibundiensi* Schltr. et *B. kamerunensi* Schltr., a quibus pseudobulbis multo minoribus monophyllis, bracteis majoribus, petalis oblongo-lanceolatis trinerviis nec linearibus facile distinguendum.

Herba terrestris ; rhizoma longe repens, teres, crassiusculum, circiter 2·5–3 mm. diametro, juventute vaginis imbricantibus obtectum. *Pseudobulbi* 2·5–3·5 cm. distantes, anguste ovoidei, 3-angulati, 1·5–2 cm. longi, circiter 1 cm. diametro, apice monophylli. *Folia* anguste oblongo-elliptica, obtusa, brevissime petiolata, 7–8·5 cm. longa, circiter 1·5 cm. lata. *Scapus* erectus, circiter 17 cm. longus ; pedunculus teres, 13 cm. longus, vaginis 6–7 arctis apiculatis vel acutis 7–8 mm. longis instructus ; rhachis carnosa, compressa, circiter 4 cm. longa, 7 mm. lata ; bracteae late ovatae, apiculatae, superne leviter carinatae, 8–9 mm. longae et latae, deinde reflexae. *Flores* fusci, e linea media utriusque rhachidis lateris exorti. *Sepalum* intermedium oblongo-lanceolatum, acutum, concavum, 8·5 mm. longum, 2·5 mm. latum ; sepala lateralia oblique falcato-ovata, acuta, 5–7 mm. longa, basi 4 mm. lata, superne reflexa. *Petala* oblongo-lanceolata, subfalcata, subacuta, 5·5 mm. longa, 1·8 mm. lata, trinervia, glabra. *Labellum* valde curvatum, ambitu elongato-ovatum, basi subcordatum, apice obtusum, omnino integrum, circiter 2·5 mm. longum, subtus carina angusta longitudinali instructum. *Columna* vix curvata, 2·5 mm. longa, alis sub stelidiis leviter dilatatis nec lobatis ; stelidia breviter subulata. *Anthera* glabra. *Ovarium* glabrum, 4 mm. longum.

Gold Coast. Imbraim, Western Province, common, Oct.–Dec., *Miles* 11. " Flowers dark brown, almost covered by large brown bract."

Another example of the fleshy rhachis type with in this case an entire lip. The exceptionally large bracts, very broad petals and small 1-leaved pseudobulbs are the characteristic features of this species.

The following new name is required owing to the existence of *B. lasianthum* Lindl., a Sumatran species :—

Bulbophyllum Simoni *Summerhayes*, nom. nov. *Megaclinium lasianthum* Kraenzl. in Engl. Bot. Jahrb. **48**, 383 (1912).

XVII.—NOTES ON THE FLORA OF SOUTHERN AFRICA : VI.*

Toddaliopsis Bremekampii *Verdoorn*, sp. nov. [Rutaceae] ; affinis *T. sansibarensi* Engl., sed foliolis minoribus oblongo-ellipticis minus acuminatis basi distincte inaequilateralibus, acumine vix obliquo, floribus ♂ in axi inflorescentiae plerumque 3-natis manifeste pedicellatisque differt.

Suffrutex vel arbor parva, 1–7 m. alta. *Folia* 3-foliolata, glanduloso-punctata ; petiolus compressus, 1–3 cm. longus ; foliola elliptica, nonnunquam obovata, apice obtusa aliquantum attenuata, basi cuneata, 2·5–6 cm. longa et 1–3 cm. lata. *Paniculae* axillares, circiter 2 cm. longae. *Flores* unisexuales. *Flos* ♂ : sepala 4, circiter 1·5 mm. longa et 1·5 mm. lata ; petala 4, oblonga, 4 mm. longa et 3 mm. lata ; stamina 8, petala aequantes ; antherae semi-exsertae ; ovarium rudimentarium 2 mm. longum. *Flos* ♀ : sepala et petala floribus ♂ similia ; staminodia 8, fere 2 mm. longa ; ovarium globosum, leviter 4-lobatum, 4-loculare vel perraro 3-loculare ; stylus brevissimus vel nullus, stigmate peltato ; ovula dua in loculis. *Fructus* ± globosus, leviter 4-lobatus, valde tuberculatus, circiter 1·3 cm. diam.

South Africa. Transvaal : Zoutpansberg distr.; on northern slopes at the western extremity of the Zoutpansberg range, *Obermeyer, Schweickerdt* and *Verdoorn* 66 (type) and 156 ; *Schweickerdt* and *Verdoorn* 567 ; *Bremekamp* and *Schweickerdt* 276.

Until the discovery of this plant on the Zoutpansberg range the genus *Toddaliopsis* Engl. was known only from Zanzibar in Trop. Africa, and it was considered to be monotypic†. In 1931 Dr. C. E. Bremekamp brought to the Nat. Herb. Pretoria a fruiting specimen for identification. The characteristic fruit of *Toddaliopsis* was recognised and at the earliest opportunity the locality was again visited where the plant was found to be abundant. Flowering specimens were procured on a first visit and good fruiting material later. The specific epithet is in honour of Dr. C. E. B. Bremekamp.

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* Continued from K.B. 1934, 270.

† Verdoorn in Kew. Bull. 1926, 393, 400.

Ficus Smutsii *Verdoorn*, sp. nov. (Moraceae) ; affinis *F. Sonderi* Miq., sed foliis late ovato-cordatis vel sub-orbicularibus, fructibus breviter et dense cinereo-pubescentibus.

Arbor parva (semper ?) ; truncus pallidus, ad saxum adhæsus ; ramuli juniores breviter et dense cinereo-pubescentes. *Folia* late ovato-cordata, breviter et late acuminata, apice obtusa vel subacuta, nonnunquam sub-orbicularia, 3–7 cm. longa, 2·5–6 cm. lata, utrinque breviter et dense cinereo-pubescentia, infra prominenter reticulata (costa media non furcata) ; petioli 1–2 cm. longi, dense appresse pubescentes ; stipulae pallide brunneae, caducae, oblongo-ovatae, 1 cm. longae, 0·5 cm. latae, plus minusve sparse cinereo-pilosae. *Receptacula* axillaria, sessilia, 6–8 mm. diam., breviter et dense cinereo-pubescentia ; bracteae basales 3 mm. longae, 2 mm. latae, cinereo-pubescentes ; ostiolum poriforme, bracteis in receptaculum recte descendentibus.

South Africa : Northern Transvaal : Zoutpansberg ; Magalakwin, growing on rocks, *J. C. Smuts* in Nat. Herb. No. 17103 ; *J. C. Smuts* in Herb. Pole-Evans 1998 ; Klein Bolaaia, 14 miles East of Dongola, on rock, *Pole-Evans* 2530 ; northern slopes, Zoutpansberg range, western extremity, *Schweickerdt* and *Verdoorn* 600 (type).

In 1926 Gen. The Right Hon. J. C. Smuts collected this plant at Magalakwin, and it was found to be unlike any known species of *Ficus*. While approaching *Ficus Sonderi* in some characters, it is nevertheless quite distinct from that species, *F. Sonderi* being a large tree with spreading branches, leaves oblong, the fruits and young parts shaggy-pilose, while *F. Smutsii* is a small tree with ovate or sub-orbiculate leaves and a dense short ashy-grey pubescence covering fruits, leaves and twigs. In 1929 Dr. I. B. Pole-Evans collected a specimen from near Messina, which compared exactly with that from Magalakwin.

During April of last year Dr. Schweickerdt and the author, while on a botanical survey of the area surrounding the Zoutpan which lies at the western extremity of the Zoutpansberg range, came upon a cave at the back of which a whitish stem about 1 ft. in diameter was observed threading its way up the face of the rock. On investigation the cave was found to have an upper mouth and from it a tree was protruding, evidently produced from the stem appressed to the rock. Specimens were collected and these proved to be the same as the material from Magalakwin and Klein Bolaaia near Messina. The name is in honour of Gen. Smuts who first collected the species.

Euphorbia aeruginosa *Schweickerdt*, sp. nov. [Euphorbiaceae] ; affinis *E. Schinzii* Pax, sed colore ramorum et podariis rubiginosis saepe 5-aculeatisque differt.

Fruticulus succulentus, spinosus, aphyllus, usque ad 15 cm. altus, multi-ramosus. *Rami* plerumque subcylindrici (indistincte 4-angulati), 0·5–0·75 cm. diam., glabri, aeruginosi, saepe spiraliter contorti, faciebus lateralibus indistincte concavis, podariis corneis

rubiginosis validis 5-aculeatis praeditis. *Podarii* quadrifarii, nunquam confluentes, 5–7 mm. longi et 3 mm. lati, apice fere truncato. *Aculei* superiores fere 4 mm. longi, medii usque ad 20 mm. longi ; aculeus inferior (si adest) fere 1·5 mm. longus. *Cyma* sessilis, ternis cyathiis. *Cyathia* infundibuliformia, lutea, glabra, 3 mm. diam., ad basin bi-bracteata, quinquis lobis obovatis fimbriatis et glandulis transverse oblongis integris munita. *Margo glandulae* intra leviter recurvatus. *Ovarium* glabrum, breviter pedicellatum, inclusum. *Styli* 2 mm. longi, ad basin breviter connati, articulati, apice minute bifidi vel subintegri. *Capsula* breviter pedicellata, partim exserta, 3 mm. diam., trilobata glabraque. *Semina* (immatura) tuberculata.

South Africa. Transvaal : Zoutpansberg distr.; on northern slopes of the Zoutpansberg range, *Obermeyer, Schweickerdt* and *Verdoorn* 151 (syn-type) ; *Schweickerdt* and *Verdoorn* 688 (syn-type) ; *van Balen* s.n.

This species is a typical chasmophyte. It grows in the fissures between rocks where it forms dense clusters up to 25 cm. in diameter. Growing in exposed situations these plants present a striking appearance ; the bright copper-green of the stems contrasts strongly with the shiny bright reddish-brown 4-ranked shields bearing the spines.

Caralluma maculata *N. E. Br.* in Fl. Tr. Afr. **4,** pt. 1, 487 (1904). *C. grandidens* Verdoorn in Fl. Pl. S. Afr. t. 518 (1932).

The description of *C. maculata* was drawn up from dried material, a task which in succulent plants always proves to be a very difficult one. Several inaccuracies in this description account for the fact that Nat. Herb. Pretoria no. 15,271 was not identified as that species but was considered to be closely allied yet distinct (*C. grandidens* Verdoorn, l.c.). The corolla-lobes of C. maculata are described as being " ½ lin." wide. Examination of the type in Herb. Kew leads one to believe that this is a typographical error which probably should read " 4 lin." wide. Comparison of the material and the figure of *C. grandidens* with the former species has furthermore shown both plants to be one and the same species. *C. grandidens* Verdoorn is consequently invalidated by *C. maculata* N. E. Br. For purposes of identification, the description of the latter species should be amended from or replaced by the description of the former species which is accurate, since it was based on living material.

Dicoma prostrata *Schweickerdt,* sp. nov. [Compositae] ; affinis *D. eleganti* Welw. ex Hoffm., sed foliis supra appresse resinoso-lanatis glandulosisque, flosculis minoribus, bracteis involucralibus abruptius et longius attenuatis, setis pappi basi haud dilatatis differt.

Herbacea, basi lignescens, caule ramisque tomentosis, foliosis, prostratis. *Folia* linearia, usque ad 4 cm. longa et 1·25 mm. lata, acuta, subrigida, supra resinoso-lanata glandulosa et costa intermedia immersa, subtus densissime albo-lanata et costa intermedia elevata,

margine irregulariter minute dentata. *Capitula* majuscula, usque ad 3 cm. longa et 2 cm. diametro, inter folia suprema sessilia, solitaria. *Bracteae involucrales* ∞ seriatae, erectae vel patentes haud recurvatae, glabrae, nitidae ; infimae stramineae, subrigidae ; superiores pallide lilacinae, anguste lanceolatae, usque ad 2 cm. longae et 3 mm. latae, in mucronem longum tenuemque attenuatae. *Setae pappi* homomorphae, pallide stramineae, barbellatae, basi haud dilatatae. *Achaenia* ignota.

Transvaal Province : Waterberg District ; 23 miles north of Nylstroom, on rocky slopes in open woodland, June 1930, *J. B. Gillett* 3807 (type).

Dicoma montana *Schweickerdt*, sp. nov. [Compositae] ; a *D. Galpinii* Wilson foliis multo minoribus, supra haud glandulosopunctatis, utrinque albo-lanatis, bracteis extra dense arachnoideis bene distinguitur ; affinis *D. Nachtigalii* O. Hoffm., sed capitulis valde pedunculatis, flosculis minoribus et bracteis angustioribus differt.

Frutex nanus, lignosus, multi-ramosus ; innovationes usque ad 12 cm. longae, dense albo-lanatae. *Folia* usque ad 2 cm. longa et 1 cm. lata, late lanceolata vel ovata, breviter petiolata, basi cuneata, apice acuta vel obtusa, margine minute serrata, supra sparse lanata ac eglandulosa, subtus dense lanata. *Capitula* solitaria, pedunculata, late campanulata, usque ad 1·5 cm. longa et 2 cm. diam., aranachnoidea. *Bracteae* ± 7-seriatae, linearilanceolatae, apice attenuatae et scabridae, rigidae et recurvatae, extra arachnoideae intus glabrae. *Setae pappi* homomorphae, stramineae, 4–5 mm. longae, barbellatae. *Achaenia* pilis stramineis adscendentibus ornata.

Transvaal Province : Zoutpansberg District ; Blaauwberg, 1500–1650 m., May 1933, *Leeman* 68 (type).

Loudetia filifolia *Schweickerdt*, sp. nov. [Gramineae] ; affinis *L. flavidae* (Stapf) C. E. Hubbard, sed culmis brevioribus gracilioribus basin versus ramosis, foliorum laminis angustioribus et brevioribus, panicula et spiculis minoribus differt.

Gramen perenne, caespitosum, basin versus ramosum ramis intravaginalibus. *Culmi* erecti, usque ad 35 cm. alti, gracillimi, striati, glabri laevesque, plerumque 1–2-nodes ; internodia exserta ; nodi minutissime pubescentes. *Folia* plerumque 5–7, 3–4 basin versus disposita, cetera remota ; vaginae glabrae vel minutissime asperulae, inferiores persistentes, nonnunquam leviter sericeovillosae, nunquam in fibras rigidas fissae, superiores glabrae ; ligulae ciliolatae, saepe setis longis marginalibus instructae ; laminae involutae, curvatae, anguste lineares, apicem versus attenuatae, usque ad 10 cm. longae et 2·0 mm. latae, valde nervatae, supra minute pubescentes, subtus glabrae, marginibus minute ciliatis. *Panicula* usque ad 7·5 cm. longa, erecta, leviter contracta, nunquam spiciformis ; rhachis angularis, tortuosa, striata, minute pubescens ;

rami circiter 2·5 cm. longi, solitarii vel bini vel trini, filiformes, inaequales, pubescentes, basi barbati. *Spiculae* solitariae vel binae, dilute fuscae, usque ad 7 mm. longae. *Gluma inferior* 3-nervis, ovata, 3·5 mm. longa, minute pubescens, apicem versus nonnunquam pilis paucis longioribus praedita, apice minute et inconspicue biloba et inter lobos arista usque ad 2 mm. longa instructa ; gluma superior fere 6 mm. longa, acuta, glabra vel extra pilis minutissimis praedita, 3-nervis. *Anthoecium inferum* ♂ ; lemma glabrum, acutum, fere 5 mm. longum, 3-nerve ; palea membranacea, glabra, 2-carinata, carinis minutissime ciliatis. *Anthoecium superum* ♀ ; lemma fere 4 mm. longum, sericeo-villosum, 9-nerve, bilobum, lobis brevissimis acutis ; arista pubescens, circiter 20 mm. longa, columna aristae 8 mm. longa ; callus truncatus vel leviter emarginatus, barbatus, 0·5 mm. longus ; palea 3·5 mm. longa, 2-carinata, carinis minutissime ciliatis. *Antherae* 3, 2·5 mm. longae. *Caryopsis* ignota.

Transvaal : Zoutpansberg District ; Zoutpan, frequent in rock-crevices on northern slopes of the Zoutpansberg, *Schweickerdt and Verdoorn* 523.

Sporobolus Schlechteri *Schweickerdt*, sp. nov. [Gramineae] ; affinis *S. centrifugo* Nees, sed vaginis basalibus opacis tenuioribus et spiculis paullo minoribus differt. *S. centrifugus* Stent in Bothalia **2**, pt. Ib, 259 (1927), non Nees.

Gramen perenne, caespitosum. *Culmi* simplices, graciles, erecti, glabri laevesque, 1–2 nodi, usque ad 40 cm. alti; internodia plerumque exserta ; nodi glabri. *Foliorum vaginae* basales breves, latae, dense imbricatae, valde striatae, glabrae, pallidae, opacae nunquam nitidae, persistentes, superiores glabra, striatae, marginibus ciliatis ; ligulae brevissime ciliolatae ; laminae lineares, in apicem longe attenuatae, planae vel involutae, 2–3·5 mm. latae et usque ad 25 cm. longae, marginibus pilis rigidis e tuberculis minutis ortis ceterae glabrae. *Panicula* erecta, ovata, laxa vel plus minusve leviter contracta, 2·5–5 cm. lata, usque ad 10 cm. longa ; axis glaber, leviter flexuosa ; rami verticillati, flexuosi, superiores binati vel solitarii, filiformes, 1–3 cm. longi ; ramuli et pedicelli brevissimi. *Spiculae* paucae, apicem ramorum versus aggregatae, olivaceo-fuscae, plus minusve 3 mm. longae. *Gluma* inferior lanceolata, plerumque 1-nervis, fere 2·25 mm. longa, glabra vel minutissime puberula ; gluma superior 1-nervis, glabra vel minutissime puberula, spiculam aequans vel excedens ; lemma ovatum, acutum, 1-nerve, 3·25 mm. longum ; palea lemma aequans, truncata vel late obtusa. *Antherae* 3, 1·5 mm. longae. *Caryopsis* ignota.

Transvaal : Lydenburg District, near Lydenburg, *Schlechter* 3965, in Herb. Kew. (type).

Orange Free State: Bethlehem District, near Bethlehem, *Richardson* s.n.

Dieterlen 671 (Herb. Mus. Austro-Afric. No. 6328) is cited by Stent partly under *S. centrifugus* and partly under *S. filifolius*. The sheet of this number in the Kew Herbarium contains the same

mixture. The inflorescence of the complete specimen is referable to *S. Schlechteri*, but some of the leaves bear tubercle-based hairs on their lower surface. On the same sheet three inflorescences without bases match those of *S. filifolius* Stent.

The type (*Drege* 3894 from " steinige Höhe im Grase, zwischen Klipplaatrivier und Zwartkey " in Herb. Mus. Bot. Berol.) of *S. centrifugus* Nees as well as other specimens of *Drege* from the Windvogel mountain, Cathcart Division, all quoted by Nees under *S. centrifugus* have shiny, brownish-yellow, firm basal leaf-sheaths a character of *S. Tysonii* Stent. The syn-type number *Tyson* 1473 of the latter species in the Kew Herbarium is typical *S. centrifugus* Nees.

Examination of specimens quoted by Stent under *S. laxivaginatus* has further shown this species to be identical with *S. centrifugus* Nees. The " larger panicle " and " darker and more crowded spikelets, broader and looser sheaths " are variable in character and thus of no taxonomic value ; the basal sheaths of " a polished smoothness " are characteristic of *S. centrifugus* Nees.

The synonomy is thus as follows : **Sporobolus centrifugus** *Nees* in Fl. Afr. Austr. 158 (1841)=*S. Tysonii* Stent in Bothalia, **2,** part Ib. 262 (1927)=*S. laxivaginatus* Stent *l.c.*, 262.

Sporobolus artus *Stent* in Bothalia, 2, part Ib. 260, 272 (1927). Nees' type of *S. centrifugus* var. *angustus* (*Drege* 4261 in Herb. Mus. Bot. Berol.) agrees in every detail with specimens quoted by Stent under the above species. *S. artus* Stent l.c.=*S. centrifugus* var. *angustus* Nees in Fl. Afr. Austr. 159 (1841).

XVIII—RESEARCHES ON SILENE MARITIMA AND S. VULGARIS—XIV*.

E. M. Marsden-Jones and W. B. Turrill.

Additional Studies of Anthocyanin Inheritance and of Other Characters in S. maritima.

The breeding described in this paper involves only one stock plant (S.P. 22). The population from which this came is referred to in our papers II and III of this series (K.B. 1929, 36, 173). It may be recalled that *hybrids* between *S. maritima* and *S. vulgaris* as well as the two parents occurred at Dawlish near together. The stock-plant 22 was chosen for further investigation because of its large leaves (relative to typical *S. maritima*), its small coronal scales, and its tubercled seeds. It and all its subsequent progeny bred true to the production of over-wintering barren shoots (i.e. it was chamaephytic).

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* Continued from K.B. 1934, 389.

A.22. Lea Mount, Dawlish, Devon, on Red Sandstone cliff, 1927.

Habit : semi-prostrate, stems up to 4 dm. long ; a little anthocynanin in upper part of stems.

Leaves : linear to oblanceolate-linear, 3·2 cm. long, 6 mm. broad, colour glaucous green, margins distinctly ciliate.

Inflorescence : of 1–7 (usually 1–5) flowers, erect and actinomorphic. Bracts all strongly ciliate, lower green, herbaceous, similar to uppermost leaves, lanceolate, slightly acuminate, upper smaller, ovate-lanceolate to ovate, and becoming completely scarious.

Calyx : broadly ellipsoid in flower with a medium amount of brownish anthocyanin, becoming broadly obovoid in fruit.

Corolla : with petals divided three-quarters length of lamina, bilobed, segments and petals not contiguous or overlapping, diameter 3·3 cm.; petals 2·7 cm. long, 1·6 cm. broad, corona of small scales, no anthocyanin blotch above or below.

Androecium : fully developed, flowers hermaphrodite. Filaments white ; anthers purple.

Gynoecium : with white stigmata and pink immature seeds.

Ripe capsules : obloid, without the teeth 7 mm. long, 8 mm. broad, mouth 5.5. mm. in diameter ; teeth each an isosceles triangle, reflexed, 3 mm. long, 2 mm. broad ; carpophore 3 mm. long, 3 mm. diameter.

Mature seeds : tubercled.

N.55.—Stock plant A.22 selfed.

40 plants in family.

Habit : semi-prostrate, stems up to 4 dm. long. 13 plants without anthocyanin in stems, leaves, or calyx, i.e. the whole plant up to the corollas yellow-green. 27 plants with a little anthocyanin in the upper parts of the stems and medium amount in the calyx.

Leaves : Uniformly as in parent.

Inflorescence : of 3 to 7 flowers, erect and actinomorphic.

Calyx : broadly ellipsoid in flower.

Petals : all bilobed except one multilobed (No. 2), all with three-quarter lobing, in all plants petals and segments not overlapping or contiguous, in all plants no blotch.

Corona : 13 full scales : 22 small scales : 1 boss.

Androecium : all plants hermaphrodite.

Filaments : all white.

Anthers : 13 yellow-green : 27 purple.

Gynoecium : in all plants stigmata white. Immature seeds 25 pink : 11 pale pink : 2 white. There is complete correlation between pink seeds and anthocyanin in vegetative parts and calyx and purple anthers. All plants with yellow-green vegetative parts and calyx have yellow-green anthers and pale pink or white seeds.

Ripe capsules : with the plants scorable for fruits the following ratios were obtained :

Shape : I.3 : I–II.16 : II.11.

Teeth : R 19 : S–R 7 : S 3.

For the teeth, R indicates reflexing, i.e. a *Silene maritima* character ; S indicates spreading, i.e. an F_1 (*S. maritima* x *S. vulgaris*) character ; S–R indicates that the teeth were for the most part slightly reflexing.

Mature seeds : 1 weak armadillo : 24 tubercled : 5 strongly tubercled.

N.81. Plant 55·5 selfed. This plant was yellow-green without anthocyanin in the vegetative parts and calyx, had a full scale, yellow-green anthers, pale pink immature seeds, I–II capsule shape, reflexed teeth and tubercled seeds. 124 plants in family.

Habit : as immediate parent, stems up to 5·9 dm. long. All plants without anthocyanin in stems, leaves, or calyx, i.e. yellow-green in colour.

Leaves : uniformly as in parent.

Inflorescence : of 1 to 7 flowers, erect and actinomorphic.

Calyx : broadly ellipsoid in flower.

Petals : all bilobed, except those of Nos. 59 and 102 which were slightly multilobed, all three-quarters lobed, all petals and segments not overlapping or contiguous, in all no blotch.

Corona : 98 full scales : 17 small scales.

Androecium : all plants fully hermaphrodite, except three (Nos. 32, 79, 89) which produced some female flowers as well as hermaphrodite ones.

Filaments : all white.

Anthers : all yellow-green.

Gynoecium : In all plants stigmata white. Immature seeds 81 pale pink : 34 white.

Ripe capsules: with the plants scorable for fruits the following ratios were obtained :

Shape : I.2 : I–II. 106 : II.1.

Teeth : S–R 6 : S 103.

Mature seeds : 109 tubercled.

N.82. Plant 55.17 selfed. This plant had anthocyanin in the vegetative parts and calyx, a small scale, purple anthers, pink immature seeds, I–II capsule shape, reflexed teeth and tubercled seeds. 132 plants in family.

Habit : as immediate parent, stems up to 4·8 dm. long. 28 plants without anthocyanin in stems, leaves, or calyx, i.e. the whole plant, up to the corollas, yellow-green. 103 plants with a little anthocyanin in the upper part of the stems and a medium amount in the calyx.

Leaves : uniformly as in parent.

Inflorescence : of 1 to 5 flowers, erect and actinomorphic.

Calyx : broadly ellipsoid in flower.

Petals : all bilobed, except 17 multilobed, all with three-quarters lobing, except in 8 plants with two-thirds lobing, petals and segments not overlapping or contiguous in all except 7 plants with petals overlapping and segments not overlapping, 1 plant with segments overlapping and petals not overlapping, and 1 plant with petals and segments overlapping, in all no blotch.

Corona : 7 full scales : 98 small scales : 1 boss. In addition 3 plants showed fluctuation between scale and small scale, 19 between small scale and boss.

Androecium : all plants fully hermaphrodite except 5 (Nos. 1, 16, 48, 56, 59) which produced some female flowers as well as hermaphrodite ones.

Filaments : all white.

Anthers : 26 yellow-green, 103, purple.

Gynoecium : In all plants stigmata white. Immature seeds 103 pink : 8 pale pink : 18 white. There is again complete correlation between pink seeds and anthocyanin in vegetative parts and calyx and purple anthers. All plants with yellow-green vegetative parts and calyx have yellow-green anthers and pale-pink or white seeds. Two plants, scored, for yellow-green vegetative parts could not be scored for flower characters. They would probably have had yellow-green anthers and either pale-pink or white immature seeds.

Ripe capsules : with the plants scorable for fruits the following ratios were obtained :

Shape : I–II. 122 : II.1.

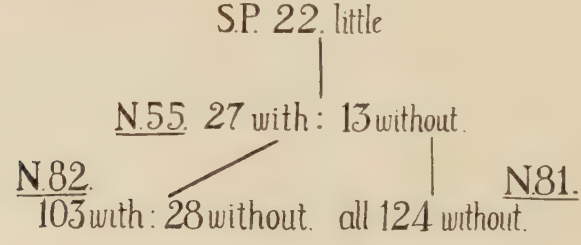
Teeth : R 14 : S–R 51 : S 58.

Mature seeds : weak armadillo 5 : tubercled 118. Of the tubercled, 21 were very weakly tubercled and verged towards weak armadillo.

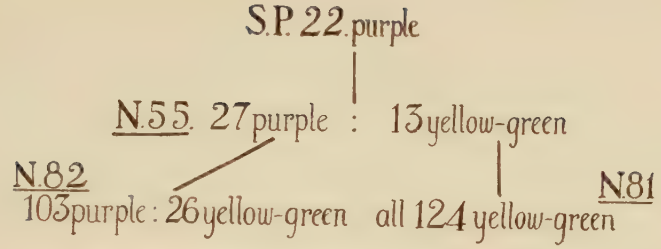
Discussion.

Anthocyanin inheritance.

For the vegetative parts and calyces the results can be shown as follows :

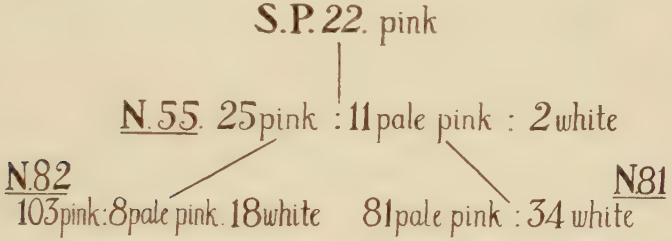


For anthers :



In S.P.22 and in all subsequent progeny the filaments and stigmata were white.

For immature seeds the following scheme illustrates the results :



It is evident that absence of colour is recessive to its presence and that plants with yellow-green foliage and calyces, white filaments, yellow-green anthers, and white stigmata breed absolutely true for these characters. It is known also, from earlier published work (e.g. *K.B.* 1932, 230, N.15, N.20, and also Addendum to the present paper, N.103) that plants with white immature seeds breed true to this character. It is further to be noted that there is exact correlation between presence and absence of anthocyanin in vegetative parts and calyces on the one hand and in the anthers on the other, in the families here considered, but not between these and anthocyanin in filaments and stigmata. Further there is exact correlation between presence of anthocyanin in vegetative parts, calyces, and anthers on the one hand and full pink seeds on the other hand, but that white and pale pink seeds are always associated with yellow-green foliage, calyces, and anthers.

Habit, leaves, inflorescences and calyces : apart from anthocyanin characters all families here discussed bred true for habits, leaf, inflorescence, and calyx characters, which were uniformly similar to those of the parent.

Corolla : lobing was constantly three-quarters, except that 8 plants with two-thirds lobing occurred in N.82. All plants were bilobed except 1 in N.55, 2 in N.81, and 17 in N.82 which were more or less multilobed. The petals in all were not contiguous or overlapping except in 9 plants in N.82. In no plants had petals an anthocyanin blotch.

Corona : the original parent (A.22) had small scales approximately of the type found in F_1, on crossing a bossed *S. vulgaris* with a full scaled *S. maritima* (see *K.B.* 1928, 2, fig. 5). On selfing segregation occurred with 13 scales : 22 small scales : 1 boss. Selfing one of the plants with scales the ratio 98 scales : 17 small scales appeared, apart from fluctuating intermediates, and on selfing one of the small scale plants the ratio 7 scales : 98 small scales : 1 boss. Although no simple genetical explanation can be given to these figures it is evident that a plant with full scales shows this character predominantly in its offspring and plants with small scales have mainly offspring with small scales.

Sex : the original parent and all subsequent progeny were hermaphrodite except 3 plants in N.81 and 5 in N.82 which produced some female flowers in addition to hermaphrodite ones.

Ripe Capsules : the original parent had obloid (II) capsules and gave on selfing I.3 : I–II. 16 : II. 11. The two subsequent families were taken from plants with intermediate capsules and gave progeny mainly with intermediate capsules.

Reflexing of teeth of capsule : the original stock plant had reflexed teeth (a *Silene maritima* character). No plants with erect teeth (a *Silene vulgaris* character) appeared in the offspring but plants with more or less spreading teeth appeared in N.81 and N.82 in predominant numbers.

Mature seeds : these were tubercled in all families except that one weak armadillo appeared in N.55 and five in N.82.

Comments.

(1) It is suggested that both phenotypically and genotypically S.P.22 has shown indications of ancestral hybridization with *S. vulgaris*. Its foliage is not unlike that found in some *S. vulgaris* plants, though it breeds true for foliage characters. Again, the corona showed an intermediate stage of development between that typical for *S. maritima* and that typical for *S. vulgaris*. In the offspring segregation occurred for this character with the appearance of both full scales and bosses. Further support is given to the suggestion by segregation for the capsule character of reflexing or spreading teeth. The field studies already referred to indicate how the hybridization could have occurred.

(2) In dealing with wild material in *Silene* and in other genera, we do not find, with some exceptions, the clear-cut segregation and simple ratios recorded for so many cultivated plants. Our evidence is cumulative and we feel must now have considerable significance. While one nearly always finds dominant or semi-dominant characters that are introduced in a cross appear in predominant numbers in later families, it seems that interaction of many factors, and even the action of the whole " genic background " is usually more pronounced in wild than in long cultivated and long selected material.

The difficulty of scoring in wild material is frequently enhanced by the occurrence of " fluctuations " which overlap in a peculiar

manner with characters having a genetic base. Such fluctuations occur for example, in the " sex " of flowers, in calyx shape, petal lobing, coronal development, and capsule shape, as well as in other characters, *on the same individual plant*. In general, fluctuations of the type exemplified are greater and more frequent in plants heterozygous for the characters concerned than in corresponding homozygotes. The problems arising from this comment are being carefully considered.

Summary.

An account is given of selfing a wild plant of *S. maritima* through two generations. It is shown that there is evidence for ancestral crossing with *S. vulgaris* which has modified the plant phenotypically and has led to some heterozygosity not usually found in *S. maritima*. Ratios obtained by the analysis of the characters being studied in this series of papers are given and some of them correlated with previously obtained results.

Addendum.

In the eighth paper of the series we dealt, *inter alia*, with the genetics of anthocyanin inheritance in *S. maritima*. Three F_1 families from intercrossing three stock plants were analyzed, and F_2 families from two of these F_1's were also analyzed. An F_2 family from the third F_1 (N.21, i.e. S–P 7 × S–P 12) has since been raised. The following is an account of the results obtained.

N.103. N.21 plant 1 selfed. 60 plants in family.

Habit : as in immediate parent and uniform. Whole plant absolutely devoid of anthocyanin.

Leaves, Inflorescence, and Calyx : as in immediate parent and uniform.

Corolla : petals in all plants overlapped. Segments in 30 plants overlapped or were contiguous in 30 they did not. Lamina lobed three-quarters. Scales well developed. No anthocyanin blotch. In 25 plants petals bilobed. In 35 plants petals multilobed.

Androecium : with filaments of all plants white, anthers yellow-green ; 32 plants with hermaphrodite flowers only, 21 plants with hermaphrodite and female flowers, 7 plants with female flowers only.

Gynoecium : with stigmata and immature seeds white.

Ripe capsules : of 20 plants broadly ovoid, of 40 obloid.

Mature seeds : of all plants armadillo.

The above results indicate that S.P.7 and S.P.12 had not between them the complementary factors for anthocyanin development in any organ.

The research on which this paper is based has been aided by a Royal Society Government Grant.

XIX — RESEARCHES ON SILENE MARITIMA AND S. VULGARIS—XV.*

E. M. Marsden-Jones and W. B. Turrill. Second selfed families from a wild stock-plant of S. vulgaris.

In paper five of this series (K.B. 1931, 119) we described a wild stock plant (No. 5) from Potterne Field, Wilts., and in paper six (K.B. 1931, 348) a family of selfed offspring (N.12 or x 12). Two plants of this N. 12 family were selfed and the analysis of the results obtained is given in this paper. The plants were especially chosen in the hope of obtaining further information on the modification of the testa pattern we have named " weak armadillo."

N. 101. = N. 12·251 selfed. 72 plants in family.

Anthocyanin in vegetative parts : 67 much : 2 little : 2 none.

Two plants had shining green surfaces, the remainder were mat.

Indumentum : 26 few hairs : 45 glabrous.

Habit : all plants ascending from a slight basal spread. Maximum stem height 7 dm. Over-wintering barren shoots were not present above ground, i.e. the plants were hemicryptophytes.

Leaves : in all plants these were uniform for *S. vulgaris*.

Inflorescence : with up to 144 flowers, which were all of the zygomorphic shape.

Calyx : in all plants inflated and with medium anthocyanin.

Petals : in all plants white and bilobed with ¾ lobing, no anthocyanin blotch. Petals and segments not overlapping or contiguous, except in No. 25 the petals overlapped and in No. 29 the segments overlapped. 8 small scale : 57 boss.

Androecium : all plants with anthers had these purple. Filaments 11 purplish : 36 white.

Sex : 30 plants had hermaphrodite flowers only, 17 had hermaphrodite and female flowers, 18 had female flowers only.

Gynoecium : stigmata 28 plants purplish : 37 plants white. All plants had white immature seeds.

Mature capsules : I. 8 : I.–II. 33 : II. 10.

Mature seeds : of all plants armadillo.

N. 102. = N. 12·172 selfed. 19 plants in family.

Anthocyanin in vegetative parts : 17 much : 1 little. 8 shining green : 9 mat.

Indumentum : 3 medium : 7 few hairs : 8 glabrous.

Habit : as in N. 101.

Leaves : as in N. 101.

Inflorescence : as in N. 101.

Calyx : as in N. 101.

Petals : in all plants white and bilobed, with ¾ lobing except in one plant with ⅔ lobing, no anthocyanin blotch. Petals and seg-

* Continued from K.B. 1935, 215.

ments not overlapping or contiguous, except in No. 12 where the segments overlap, all with boss.

Androecium : all plants with anthers (6 only) had these purple and the filaments white.

Sex : 4 plants had hermaphrodite flowers only, 2 had hermaphrodite and female flowers, 9 had female flowers only.

Gynoecium : stigmata 3 plants purplish : 12 plants white. All plants had white immature seeds.

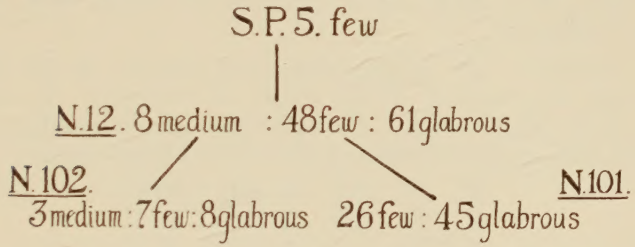
Mature capsules : I. 1 : I.–II. 9 : II. 5.

Mature seeds : 5 weak armadillo : 10 armadillo.

Discussion

Anthocyanin. None of the plants in these families is the equivalent of the yellow-green plants previously analysed in *S. maritima* and probably all plants were genetically capable of producing anthocyanin. The degree of production is here probably due to fluctuation within one genotype.

Indumentum.



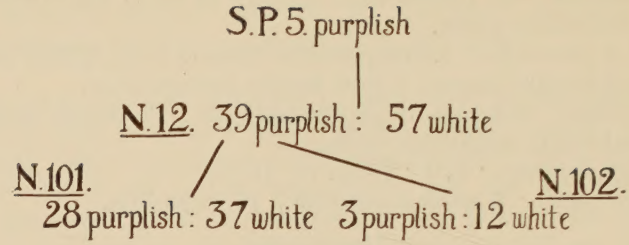
As in previous research on indumentum the degree of hair development in the offspring family as a whole is correlated with the degree of hair development in the parent or parents.

Corona. In N. 12 only one plant (among 117) had small scales, the rest like the immediate parent had bosses. The small scaled plant on selfing gave 8 small scales : 57 boss. A plant with bosses gave all bosses in the offspring on selfing. A plant with small scales was found in the wild in the same locality. There can be no question of recent contamination with *S. maritima*, though F_1 plants of *S. vulgaris* × *S. maritima* have a similar coronal development.

Androecium. The original stock plant and its offspring No. 251 were heterozygous for filament colour. No. 172 was also probably heterozygous but the only six plants scorable for the character had white filaments. Absence of colour on filaments does not necessarily involve absence of colour in anthers or stigmata.

Sex. The original stock plant had hermaphrodite and female flowers and gave 39 ☿ : 17 ☿ + ♀ : 41 ♀. The immediate parents of N. 101 and N. 102 had hermaphrodite flowers only and their offspring segregated in the ratios 30 ☿ : 17 ☿ + ♀ : 18 ♀ and 4 ☿ : 2 ☿ + ♀ : 9 ♀. We know that only so-called " fixed " females and " fixed " hermaphrodites breed true and obviously Nos. 172 and 251 do not belong to these categories.

Gynoecium.
Stigmata



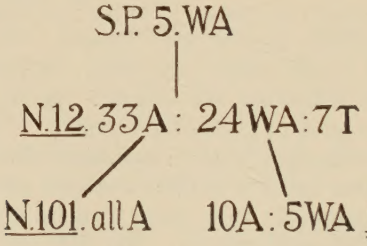
N. 101. 28 purplish : 37 white 3 purplish : 12 white **N. 102.**

The parents and grandparent had purple stigmata but were heterozygous for this character, though in all three families the white stigmata are more numerous than coloured stigmata. N. 101 and N. 102 bred true for white immature seeds, though both families came from white seeded parents extracted from a purple seeded grandparent.

Ripe capsules. The grandparent and parents of N. 101 and N. 102 had intermediate (I–II) types of capsules. In all three families most plants had I–II capsules, a much smaller number II, and a still smaller number I, the exact figures being :

N. 12.	6 I :	40 I–II :	19 II
N. 101.	8 I :	33 I–II :	10 II
N. 102.	1 I :	9 I–II :	5 II

Mature seeds. The grandparent had weak armadillo seeds and the following scheme shows the results obtained.



As always in our experience plants with armadillo seeds breed quite true for this character. It is further completely recessive to tubercled seeds when parents clearly homozygous for these characters are used, no weak armadillo or other morphologically intermediate type of seed appearing. The N. 12 ratio is 8 : 6 : 2 or 4 : 3 : 1 and the N. 102 ratio is 2 : 1.

SUMMARY.

The results obtained by selfing two individuals from a family derived by selfing a wild stock plant of *S. vulgaris* are given.

Segregation is shown to occur for medium indumentum and few hairs, for small scale, filament colour, sex, stigmata colour, capsule shape, and weak armadillo testa. Armadillo testa breeds true.

The research on which this paper is based has been aided by a Royal Society Government Grant.

XX.—MISCELLANEOUS NOTES.

The Silver Jubilee of His Majesty the King.—By command of H.M. the King, the Silver Jubilee Medal has been awarded to The Director, to Mr. A. D. Cotton, O.B.E.. Keeper of the Herbarium and Library, and to Mr. J. T. Hazel, Ganger in the Alpine and Herbaceous Department, who has been in the employment of the Royal Botanic Gardens for nearly 38 years.

Sir David Prain.—We record with pleasure that the Council of the Linnean Society has awarded the Linnean Gold Medal for 1935 to Sir David Prain, C.M.G., F.R.S., Director of the Royal Botanic Gardens, Kew, from 1905 to 1922.

The Director.—The Director has been elected an Honorary Member of the Orchid Circle of Ceylon, and a Corresponding Member of the Netherlands Botanical Society.

Harold Musk.—We record with deep regret the death of Mr. Harold Musk from Blackwater Fever in hospital at Dar-es-Salaam on April 20th. He came to Kew as a student gardener on March 24th, 1924, and left on September 26th, 1925, on being awarded a Colonial Agricultural Scholarship by the Secretary of State for the Colonies.

The first year of his Scholarship was spent at Wye Agricultural College, and during the second year he studied at the Imperial College of Tropical Agriculture, Trinidad. Before coming to Kew he had received part of his early training at the Royal Gardens, Sandringham.

On the completion of his course at Trinidad in 1928 Musk was appointed to the post of District Agricultural Officer, Tanganyika (K.B. 1928, 112), and served in that Territory until his untimely death. Harold Musk was the first Kew student gardener to be awarded one of the Colonial Agricultural Scholarships and his death at the early age of 36 is a very sad loss.

A monographic study of Abies numidica Lann.—The species of *Abies* in Europe and the Mediterranean Region are morphologically very closely related to one another and are taxonomically difficult to define. This is particularly true of those of the Balkan Peninsula and Asia Minor.

M. Barbey has published a useful account* of the Algerian fir as it occurs in the restricted area of Mont Babor, which reaches to an altitude of 2004 m. in central Algeria. This is largely a field study of the natural conditions under which the woods are growing and is illustrated by a series of photographic plates, some very excellent. A preface by M. Guinier discusses the general problems connected with the genus *Abies* in the Mediterranean Region. Chapters in the body of the work are concerned with the relationships of *A. numidica* to other species, the ecology of the Babor forests, the insect fauna of the area, and suggestions for the administration and preservation of the woodlands.

W. B. TURRILL.

Botanical Magazine.—The first part of vol. 158 was published on February 20th, 1935. The new volume differs from previous volumes in having the plates printed on a whiter paper, which renders the colouring more vivid and accurate, and also, in some cases, in having the dissections and small figures placed in the text, instead of on the plates. This new arrangement is a distinct improvement from the artistic point of view and is also useful since the figures are placed in the text where reference is made to structural details.

The following plants are figured: *Anguloa brevilabris* Rolfe (t. 9381) from Colombia; *Semiaquilegia ecalcarata* Makino & Cox (t. 9382), a native of Kansu, Shensi and Szechuan, China; *Rhododendron Roxieanum* Forrest (t. 9383), from Western China and S. E. Tibet; *Primula szechuanica* Pax (t. 9384), from W. China and S. E. Tibet; *Choananthus cyrtanthiflorua* (C. H. Wright) Rendle (t. 9385), first discovered on Mt. Ruwenzori in 1893-94 and known from the Belgian Congo and Uganda; *Medinilla gratiosa* Stapf (t. 9386), from the Malay Peninsula; *Cyananthus longiflorus* Franchet (t. 9387), discovered by Père Delavay in Yunnan and introduced by the late Mr. G. Forrest; *Rhododendron Wiltonii* Hemsl. & E. H. Wilson (t. 9388), from W. Szechuan; *Cotoneaster hebephylla* Diels var. *monopyrena* W. W. Smith (t. 9389), a native of N.W. Yunnan; *Phlox maculata* L. × *P. paniculata* L. (t. 9390), a fine garden hybrid which flowered in the Glasnevin Botanic Garden, Dublin, and *Linearia faucicola* Levier & Leresche (t. 9391), an interesting rock garden plant from Northern Spain.

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* By A. Barbey: Une Relique de la Sapinière Mediterranéene, le mont Babor, Paris 1934. Pp. 84.

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